General Report;

Survey of India

1881-82 to 1882-83

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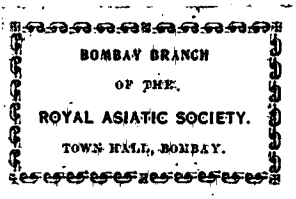

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GENERAL REPORT

ON THE

Operations of the Survey of India,

COMPRISING

THE GREAT TRIGONOMETRICAL, THE TOPOGRAPHICAL, AND THE REVENUE SURVEYS UNDER THE GOVERNMENT OF INDIA,

DURING

1881-82. 1882-83

PREPARED UNDER THE SUPERINTENDENCE
OF
LIEUTENANT-GENERAL J. T. WALKER, C.B., R.E., F.R.S., &c.,
Surveyor-General of India.

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PRINTED AT THE BENGAL SECRETARIAT PRESS.
1883.

SPECIMEN OF HELIOGRAVURE BY MAJOR WATERHOUSE'S PROCESS.

VIEW OF KANCHINJUNGA FROM DARJEELING, FROM A SKETCH BY Lt COLONEL C. J. CRAMER ROBERTS.

Reproduced in heliogravure, at the Surveyor General's Office, Calcutta.

March 1883.

See Appendix, page 99

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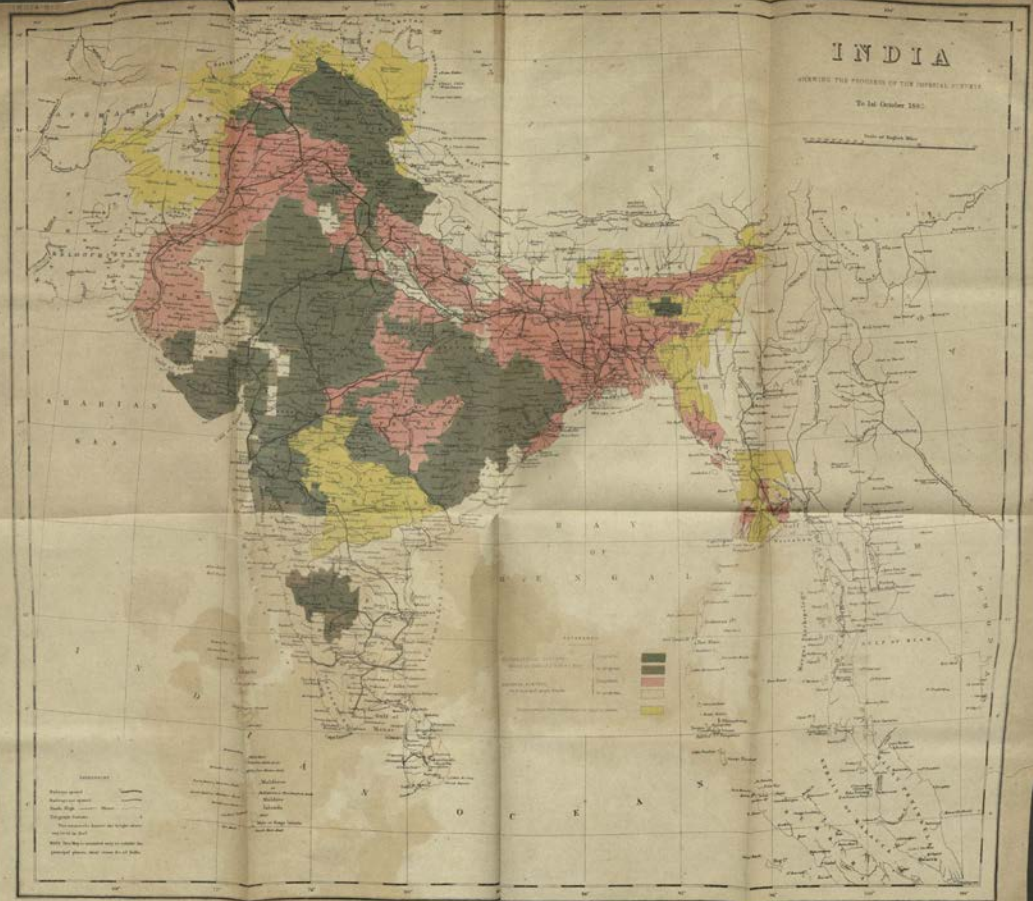


Published under the direction of Lieut.-General H. L. THUILLIER, R.E. F.R.S. Surveyor General of India.
Surveyor General's Office, Calcutta, December 1857.

GENERAL REPORT

OF THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1881-82.

INTRODUCTORY.

THE general direction of the Survey Department, and the immediate supervision of the Trigonometrical and Topographical Branches, have been performed by Lieutenant-General J. T. Walker, C.B., R.E., Surveyor-General. The immediate supervision of the Revenue Branch has been performed by Lieutenant-Colonel J. Sconce, S.C., Deputy Surveyor-General.

2. The principal operations which have been carried out during the survey year under review, viz. from 1st October 1881 to 30th September 1882, are as follows :—

Statement of Survey Operations and Parties.

Number in this Report.	Nature and Locale of Operations.	Names of Executive Officers.	Designations of Survey Parties.	Remarks.
	Base Line and Triangulation.			
I	Mergui and Eastern frontier.	Lieut.-Colonel B. R. Branfill. Major M. W. Rogers ...	Bombay party ... Eastern frontier party.	Base-line—principal triangulation—collateral astronomical operations.
	Topography.			
II	Central India	Major C. Strahan, R.E. ...	No. 1 Topographical Survey	1-inch scale for reproduction.
III	Khandesh	„ T. T. Carter, R.E. ...	No. 2 Topographical Survey.	2-inch scale for reproduction.
IV	Malwa	„ J. R. Wilmer, S.C. ...	No. 5 Topographical Survey.	1-inch scale for reproduction.
V	Sylhet	Lieut.-Colonel R. G. Woodthorpe, R.E.	No. 6 Topographical Survey.	2-inch and ½-inch scales for reproduction.
VI	Rajputana	Mr. G. A. McGill	No. 7 Topographical Survey.	½-inch scale for reproduction.
VII	Mysore	Major H. R. Thuillier, R.E.	No. 8 Topographical Survey.	1-inch scale for reproduction.
VIII	Kohat	„ T. H. Holdich, R.E....	Kohat Topographical Survey.	
IX	Guzerat	Colonel C. T. Haig, R.E. ...	Guzerat Survey ...	2-inch scale for reproduction on same scale and reduction to 1-inch scale.
X	Cutch	Lieut.-Col. A. Pullan, S.C....	Cutch Survey ...	2-inch scale for reduction to 1-inch scale and ½-inch scale for reproduction
XI	Meerut Division, N.-W. P.	Mr. E. T. S. Johnson ...	No. 3 Revenue Survey.	2-inch scale for reproduction to same scale, and for reduction to 1-inch scale.
XII	South Deccan	Major D. C. Andrew, S.C....	No. 11 Revenue Survey.	2-inch scale for reduction to 1-inch scale.
XIII	Hooghly River Survey ...	Bt. Lieut.-Col. E. T. Beach, V.C., R.E. Major S. H. Cowan, S.C. ...	No. 6 Revenue Survey.	On Hooghly river; partly on 16-inch, and partly on 6-inch scale, for reproduction to same scales.
XIV	Beluchistan	Major R. Beavan, S.C. ...	Beluchistan Survey ...	½-inch and ¼-inch scales for reproduction.

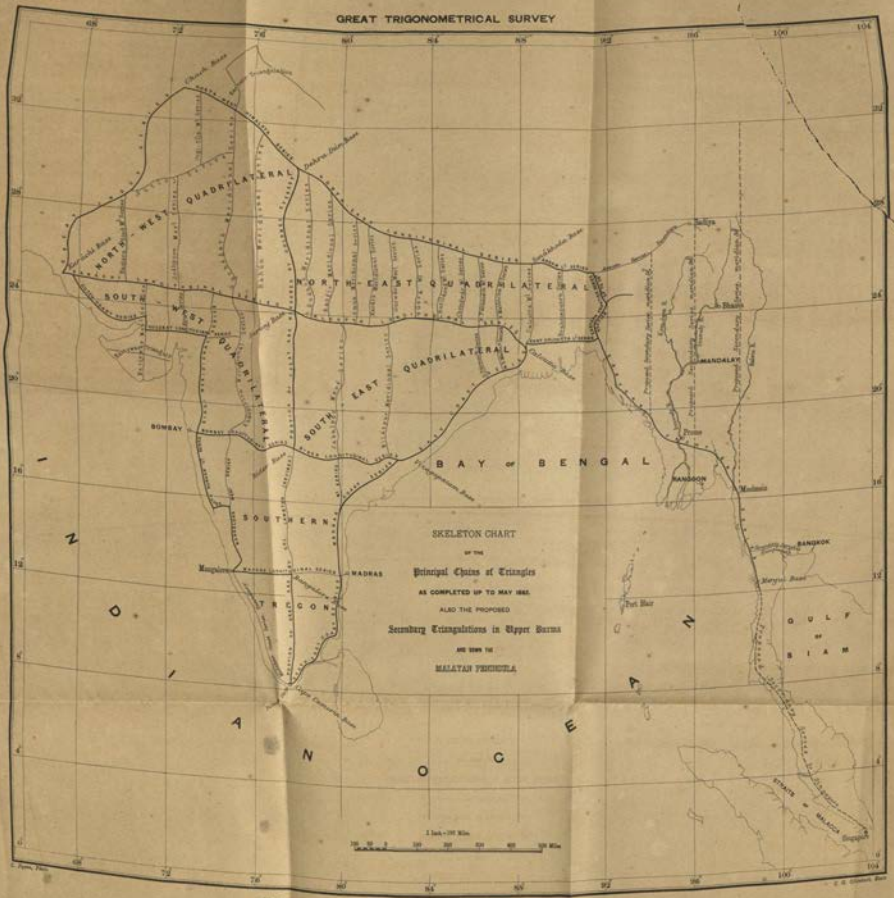
Number in this Report.	Nature and Locale of Operations.	Names of Executive Officers.	Designations of Survey Parties.	Remarks.
	Monzawar or Village Survey.			
XV	Rawalpindi, Dera Ismail Khan, and Muzaffargarh, Punjab.	Lieutenant-Colonel D. Macdonald, S.C.	No. 1 Revenue Survey.	4-inch scale. In Rawalpindi for reproduction to same scale, and in all districts for reduction to 1-inch scale.
XVI	Konkan	Major H. Lees Smith, S.C. „ J. Hill, R.E. ...	No 10 Revenue Survey.	4-inch scale for reproduction to same scale and for reduction to 1-inch scale.
	Cadastral or Field Survey.			
XVII	Mirzapur and portions of Tarai district, N.-W. P.	Colonel F. C. Anderson, S.C.	No. 5 Revenue Survey.	16-inch scale for reproduction to same scale and for reduction to 1-inch scale.
XVIII	Gazipur, Ballia, and Banaras districts. Ganges River Survey, district Shahabad.	Major W. Barron, S.C.	No. 4 Revenue Survey.	In district Shahabad 4-inch survey, *not for publication.*
XIX	Hanthawaddy district and Arakan waste land grants.	Major J. R. McCullagh, R.E.	No. 2 Revenue Survey.	16-inch scale for reproduction to same scale, also for reduction to 2-inch and 1-inch scales.
XX	Bassein district	„ W. H. Wilkins, S.C.	No. 3 Revenue Survey.	In Arakan, skeleton boundary survey on 16-inch scale, *not for publication.*
XXI	Tharawaddy district ...	Mr. H. B. Talbot ...	No. 7 Revenue Survey.	
XXII	Sylhet Test Survey ...	...,...	No. 6 Revenue Survey.	16-inch scale to test settlement survey.
	Miscellaneous.			
XXIII	Darjeeling	Captain H. J. Harman, R.E.	Darjeeling Survey ...	Various scales in Darjeeling, 1-inch in Sikkim.
	Geographical.			
XXIV	Manipur boundary.			
XXV	Northern Afghanistan.			
XXVI	Dardistan and Kishanganga.			
XXVII	Trans-Himalayan explorations. 1. Badakshan. 2. Frontiers of Sikkim. 3. Great Tibet.			
	Tidal and Levelling Operations.			
XXVIII	Tidal operations.	Major M. W. Rogers, R.E., and Major J. Hill, R.E.	Tidal and Leveling Party.	
XXIX	Tidal disturbances by earthquake.			
XXX	Spirit-leveling operations.			
	Geodetic.			
XXXI	Electro-telegraphic determination of longitudes.	Major G. Strahan, R.E., and Major W. J. Heaviside, R.E.	Nos. 1 and 2 Astronomical Parties.	

TRIANGULATION.

3. The chain of principal triangles, known as the Eastern Frontier Series, which in previous years had been carried from Assam through Arakan and British Burma into Tenasserim, has this year been brought to a close on a base-line of verification in Mergui, thus finishing the principal triangulation of all India on the lines originally marked out by Colonel Everest and sanctioned by the Hon'ble Court of Directors of the East India Company

4. The completion of this great undertaking necessitates a brief review of the operations in the present report. It originated in a so-called "mathematical and geographical survey" which was commenced in Southern India in the year 1800 by Major Lambton, of Her Majesty's 33rd Regiment of foot, on the recommendation of the Hon'ble Colonel Wellesley, afterwards the first Duke of Wellington. Its object was, in Major Lambton's words, to "determine the exact positions of all the great objects that appeared best calculated to become permanent geographical marks, to be hereafter guides for facilitating a general survey of the peninsula;" and as at that time the elements of the figure of the earth were not known with sufficient approximation

GREAT TRIGONOMETRICAL SURVEY



Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dun, September 1882.

to enable the latitudes and longitudes of the "great objects" to be computed with accuracy from the data of the triangulation, Major Lambton pointed out that his intended survey would, in the interests "of general science * * * involve many more objects than what immediately appertain to geography," and that portions of the triangulation would have to be executed with the utmost possible precision, and be supplemented by astronomical determinations of position, with a view to the requirements of geodesy.

5. The operations between the years 1800 and 1825 may be briefly described as constituting a network of triangulation over Southern India, which was grounded on, and verified by, several chain-measured base-lines, and through the middle of which a principal chain of triangles was carried in a meridional direction, from Cape Comorin up to Sironj in Central India. This chain formed the southern portion of what is now known as Lambton and Everest's Great Arc. Its angles were measured with greater care than those of the collateral network, and at certain of its stations astronomical observations were taken for the determination of the minor arcs of amplitude. Colonel Lambton died in 1823, and was succeeded by Colonel Everest, who two years afterwards proceeded to Europe, where he spent four years in supervising the construction of new instruments—great theodolites, astronomical circles, standard of length, and compensation bars for base-line measurements—for employment in extending and revising the Great Arc, the importance of which for geodetic requirements had now become so thoroughly recognised by men of science in Europe, that Colonel Everest found no difficulty in obtaining *carte blanche* from the Government of India and the Court of Directors for all the instrumental equipment which he wanted. During his absence from India a small party of surveyors was employed in carrying a longitudinal chain of triangles eastwards from the point reached by the Great Arc in Central India to Calcutta.

6. On his return from Europe, in 1830, Colonel Everest recommended the abandonment of the network system of triangulation, and the substitution instead of what he called the "gridiron" system, consisting of meridional chains of triangles tied together at their upper and lower extremities by longitudinal chains. The meridional chains were intended to be constructed at intervals of about one degree apart, while the longitudinal chains would follow the parallels of Calcutta, Bombay, and Madras, and thus run at intervals of from five to six degrees apart. The external chains of the gridiron would of course follow the British frontier lines and the coast lines. The entire triangulation was to be grounded on base-lines measured with the Colby apparatus of compensation bars and microscopes—in terms of a fixed standard of length—which were to supersede the old base-lines that had been measured with chains of comparatively rude construction and of uncertain length. This programme of operation was approved by the Government of India and the Court of Directors, and it has furnished the guiding lines on which the principal triangulation has been executed during the period of almost exactly half a century which has elapsed since it was laid down.

7. The central lines of the several chains of principal triangles are shown in the skeleton chart facing this page. For convenience of treatment in the final reduction, the whole of the chains situated within the limits of India proper have been grouped into five sections. Four of these are roughly four-sided in outline, and are respectively called the North-East, North-West, South-East, and South-West Quadrilaterals—names in which the cardinal points have reference to the Kalianpur Observatory in Central India, which Colonel Everest adopted as the origin of the operations subsequent to 1832. The fifth is three-sided, and is called the Southern Trigon. The North-East Quadrilateral was completed first of all; and here it will be seen that the meridional chains of triangles lie at intervals of about one degree apart, as originally designed by Colonel Everest. But in the sections subsequently executed the intervals between the meridional chains have been materially increased, as the minor triangulations which in course of time came to be executed by the topographical surveys were of such accuracy that a smaller amount of principal triangulation was found to suffice for all geographical requirements, and more was not wanted for geodetical requirements. An additional meridional chain might have been constructed on the meridian of 84° within the South-East

Quadrilateral, and it doubtless would have been constructed but that before it could be commenced a network of excellent topographical triangulation had been thrown over the entire area which is included between the collateral principal chains, and nothing more was wanted. Similarly, in the Southern Trigon the execution of a chain of principal triangles along the west coast, from Cape Comorin to Mangalore, was desirable for symmetry, co-ordinately with the chain on the east coast from Cape Comorin to Madras; but it was not wanted for geodesy. For geographical purposes, the Malabar Coast Series of secondary triangles was amply sufficient. It had been mostly executed by Major Lambton, and it stood connected with the modern operations. Major Lambton had not, however, attempted to throw his triangulation over the broad belt of plains on the east coast, which is covered with trees and other obstacles that he had no means of surmounting. Thus a chain of principal triangles has been carried in modern times over these plains, as it was wanted for geographical purposes. It has, moreover, furnished a base from which a branch chain of triangles has been carried across the Paumben Straits to the island of Ceylon, in order to connect the surveys of India and Ceylon.

8. For geodetic purposes, the amount of principal triangulation which has been executed is ample. The first measurement of the sections of the Great Arc between Cape Comorin and Sironj was accomplished with instruments far inferior in accuracy to those with which the liberality of the Court of Directors furnished Colonel Everest in subsequent years; and being deemed of insufficient accuracy for geodetic requirements, its revision was directed to be undertaken as soon as might be consistent with the need of triangulation for geographical purposes in other parts of India. The northern section, from Sironj down to Bider, was indeed revised under Colonel Everest's superintendence in 1838-39; but the revision of the southern sections—Bider, Bangalore, Cape Comorin—was postponed for several years, and was eventually accomplished during 1869-74. The Longitudinal Series from Sironj to Calcutta has also been revised, as it was originally executed with very inferior instrumental means; and it happens to be the most important of all the great chains of triangles, because it furnishes bases for no less than fourteen meridional chains lying to its north and south. Partial revisions have been made in other quarters of work executed with inferior instruments which it was deemed necessary to raise to a higher standard of accuracy. Outside the limits of India proper the recently completed chain of principal triangles called the Eastern Frontier Series is a valuable contribution to geodesy as well as geography.

9. The whole of the triangulation rests on ten base-lines, which have been measured with the Colby apparatus of compensation bars and microscopes, which was constructed in England under Colonel Everest's superintendence. The relations of the length of the Indian Standard to the principal European Standards of Length have been very exactly determined. Considerations of symmetry would suggest the introduction of an additional base-line near Bombay, on the same parallel as the Bider and Vizagapatam base-lines, and measured with the same apparatus. But it so happened that a chain base-line had been measured on the Karleh plain, near Bombay, in the year 1828 by Captain Shortrede, the calculated value of which through the longitudinal series from the Bider base-line agrees very closely with the measured value. It was commended by Colonel Everest, who however some years afterwards, in 1848, made preliminary arrangements for the measurement of another line in the neighbourhood with the Colby apparatus; but he did not carry out this project. Eventually the idea was abandoned, as the distance from the Bider base is comparatively small, and no material advantage, at all commensurate with the labour and expense, would be derived from the measurement of a new base; for to measure a base-line with the Colby apparatus occupies two full-strength trigonometrical parties for an entire field season, unless there happens to be other employment for the survey officers in the neighbourhood of the base. There is some uncertainty as regards the unit of length adopted by Captain Shortrede in measuring the Karleh base; consequently this base has not been employed in the final reductions, though no new base has been measured.

10. Thus the great work of the principal triangulation of India is now an accomplished fact. Commenced in 1800 under the auspices of the Madras Government, it was carried on by Major Lambton, almost single-handed, until

the year 1818, when the Marquis of Hastings, who was then Governor-General, placed it under the direct and immediate control of the Supreme Government. Captain Everest was shortly afterwards appointed assistant to Major Lambton. In 1832 additional officers were appointed, and by the year 1840, when the geodetic operations on the northern sections of the Great Arc were completed, the *personnel* sufficed for the equipment of six trigonometrical survey parties; and this number of parties was uniformly maintained from that time onwards, until it could be gradually diminished on the completion of the successive chains of triangles. The operations have been uniformly and consistently supported by the Supreme Government, with the sanction and approval, first of the Hon'ble Court of Directors of the East India Company, and afterwards of the Secretary of State for India. In times of war and financial embarrassment the scope of the operations has been curtailed, the establishments have been reduced, and some of the military officers sent to join the armies in the field; occasionally the civilians also have been sent to the seat of war, to be employed on survey duties. But whatever the crisis, the operations have never been wholly suspended. Even during the troubles of 1857-58 they were carried on in some districts though arrested in others. They have been uninfluenced by changes of *personnel* in the administration of the British Indian empire; each succeeding Governor-General or Viceroy has honoured them with his support. At the close of the mutinies Lord Canning wrote of the principal triangulation and collateral topography in Kashmir to Colonel Waugh, then Surveyor-General of India, as follows:—

"I cannot resist telling you at once with how much satisfaction I have seen these papers. It is a pleasure to turn from the troubles and anxieties with which India is still beset, and to find that a gigantic work, of permanent peaceful usefulness, and one which will assuredly take the highest rank as a work of scientific labour and skill, has been steadily and rapidly progressing, through all the turmoil of the last two years."

And up to the last moment the successive Governments have accorded their support to the operations with equal liberality and constancy. It may well be doubted whether any similar undertaking, executed in any other part of the world, has been equally favoured and supported.

11. The field operations—viz. the measurements of the base-lines and angles of the principal triangulation—being completed, the next step is the final reduction and harmonizing of the results, giving to each measurement and observation its proper weight, and nothing more or less. Strictly speaking, this undertaking should be postponed until the completion of the whole of the operations, and then all the observations should be reduced simultaneously, because every fact of observation is more or less dependent on, and connected with, every other fact. But the simultaneous reduction of the vast number of such facts acquired over all India, by many individuals and during a period of many years, was obviously impossible. Thus it became necessary to divide the triangulation of India proper into the five sections which have already been mentioned in paragraph 7 and are indicated in the accompanying skeleton chart; and even then the simultaneous reduction of the numerous facts of observation collected together in each group was a work of enormous labour, necessitating—as remarked by Colonel Clarke, C.B., of the Ordnance Survey, one of the most eminent of living geodesists, in his recent treatise on geodesy—"the most elaborate calculations that have ever been undertaken for the reduction of triangulation." The division of the work into sections necessitated the maintenance of the results determined for the sections first reduced, in the contiguous sections, when they in turn came to be reduced; and this necessitated commencement with the section which in all its parts was of the highest accuracy. The section of which the field work was first completed was the North-East Quadrilateral; but as many of its angles had been measured with instruments of inferior accuracy to those employed in the sections which were subsequently completed, the reductions were performed in the following order:—1st, the North-West Quadrilateral; 2ndly, the South-East Quadrilateral; and 3rdly, the North-East Quadrilateral. The reductions were commenced in the year 1869: the final results of the first section are given in Volumes * II, III and IV of the Account of the Operations of the Great Trigonometrical Survey, published in 1879; those of the second in Volume

* Volume I is devoted to the Base-lines, and Volume V to the Pendulum Operations.

VI, published in 1880; and those of the third, in Volumes VII and VIII, which are now in the hands of the book-binders and will shortly be published. The fourth section selected for treatment was the Southern Trigon; its simultaneous reduction is now completed, but the final results will probably not be printed and ready for publication for another year or two. The last section to be taken in hand is the South-West Quadrilateral; but the final reduction of this section has not yet been commenced, nor has that of the recently completed Eastern Frontier Series.

12. The stations of the principal triangulation are 3,472 in number. They have been constructed with a view to being as lasting and permanent as possible. On the plains they are fashioned in the form of towers rising from 20 to 40, and even 60, feet above the ground level, and usually about 16 feet square at base, with an isolated central pillar for the instruments to rest on. On hills and mounds or other eminences the central pillar—always of masonry—is raised 2 to 4 feet above the ground level, and is surrounded with a platform of earth and stones. Mark-stones, engraved with a dot and surrounding circle to define with precision the point to which the observations are referred, are inserted on the surface and at the base of each pillar. The stations are invariably placed under the protection of the local officials: they are scattered over 338 British districts and Native states, in each of which some officer is required to submit annual reports of the condition of the whole of the stations within its circle; repairs are effected whenever necessary. If the present system of protection and repairs is maintained by future generations of officials, the duration of the stations should be co-eval with that of the hills and plains on which they stand, and the great work now completed will be of lasting utility.

13. A considerable amount of secondary triangulation has been executed *pari passu* with the principal triangulation, partly by observations from the principal stations to all the most prominent objects visible from them—as the snow peaks of the Himalayan ranges—partly by the construction of chains of secondary triangles resting on the primary chains, such as have been carried to a number of important towns and cities within the limits of the empire, and of late years beyond those limits to Kandahar and Kelat on the one side, and to Bangkok on the other. Much secondary triangulation, however, still remains to be executed. It is wanted on the coast lines, to furnish fixed points for the marine surveys, and in localities in the interior at a distance from the nearest principal chains, where data may be required for topographical surveys. But it is chiefly wanted outside the limits of India proper, as for the extension of the Eastern Frontier Series through the Malayan peninsula down to Singapore, and to furnish a basis for the geography of Upper Burma. For the latter purpose three chains on the meridians of 94°, 96°, and 98° respectively are desirable, the two first of which would close on the chain of secondary triangulation already completed in the Assam Valley, while the third might be carried still further to the north. Bangkok, the capital of Siam, having already been connected with the Indian triangulation by a chain of triangles, which was recently executed with the support of the Siamese Government, it is to be hoped that the ruler of Upper Burma may soon be moved to follow the good example set by his neighbour potentate, not only in assenting to the triangulation, but in rendering all desirable assistance towards its execution. The proposed chains of triangles for Burma and the Malayan peninsula are shown in the accompanying skeleton chart. The latter has already been sanctioned by the Government of India and the King of Siam, and it would have been commenced ere this had officers and funds been available for the purpose.

14. The requirements of geodesy necessitate astronomical observations for the determination of the latitude and the azimuth, and electro-telegraphic observations for the determination of differential longitudes, at several of the stations of the principal triangulation. These have already been completed to a considerable extent. Further operations of this nature are in progress at the present time; they are carried out by the two small astronomical parties which are attached to the trigonometrical or geodetic branch of the department, and by which all the operations that are required to render the principal triangulation fully subservient to geodetic science should be completed in the course of a

INDEX CHART
TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA

few years. An extensive series of pendulum observations for investigations of variations of gravity and the figure of the earth, taken chiefly at stations of the principal triangulation, has been completed and connected with the groups of corresponding observations in other parts of the globe. Long lines of spirit-levels have been, and are still being, carried on in connection with the principal triangulation, from the sea to the base-lines in the interior, and from sea to sea across the peninsula; they rest on determinations of the mean-sea level which have been, and are being, made at the tidal stations on the coasts.

15. The Index Chart to the Great Trigonometrical Survey of India which faces this page shows the whole of the principal triangulation, distinguishing between the early operations with inferior instruments and the operations since 1830 with superior instruments; the former being indicated by fine lines, the latter by thick lines. It also shows the more important secondary triangulations which have been executed outside the limits of the principal triangulation—as to the Himalayan snow peaks, to Kandahar, and to Bangkok; but it does not give any of the large amount of internal secondary triangulation, as it could not have done so without crowding the chart greatly and causing confusion with the early principal triangulation. For this reason the modern chain of secondary triangles which connects the old principal chains on the west coast of the southern peninsula, between Cape Comorin and Ponany, and between Cananore and Mangalore, is not shown. The Index Chart also indicates the positions of the base-lines which were measured with the Colby apparatus, the stations at which astronomical observations for either latitude or azimuth, or both, have been made, the longitudinal arcs, the stations at which pendulum observations for investigations of variations of gravity have been taken, the main lines of the spirit-leveling and the tidal stations. The chart was originally engraved in 1870, but it has now been brought up to the 1st October 1882, in order to be complete up to date.

TOPOGRAPHY.

16. The regular topographical operations have been carried on in continuation of those of last year, mostly in the same provinces and by the same parties. But the completion of the Jaunpur cadastral survey last year happily set free a party for employment in making a survey of the banks of the river Hooghly, for some distance above and below Calcutta. This has now been commenced, and is being carried on *pari passu* with a survey of the bed of the river, now in progress under the orders of the Port Commissioners. Many years have elapsed since the last survey of this important portion of the river Hooghly was made; the maps are out of date and otherwise inadequate to the requirements of the present time, for their scale—4 inches to the mile—is much too small to show the valuable properties situated along the banks of the river. In fact, it may be said that up to the present time this densely-populated riverain tract, which is studded with valuable estates and factories—the property of a wealthy mercantile community of Europeans and Natives—and is of vastly greater importance than any equal stretch of river in all India, has fared little or no better in the way of maps than the poorest and least significant village lands away from the river. Thus a large scale survey of the tract had become a necessity; and the fortunate circumstance that a new survey of the bed of the river was also about to be made has enabled two important collateral surveys to be carried on simultaneously, to the mutual advantage of both.

17. A constantly growing demand has arisen of late years for new surveys, on a large scale, of districts under the administration of the British Government, in supersession of the small scale surveys which were executed a generation or more ago. The first surveys were undertaken mainly with the object of furnishing sufficiently accurate materials for the series of maps known as the sheets of the Atlas of India; and as these maps were, and still are, produced on the scale of $\frac{1}{4}$ of an inch to the mile, a close survey of local details was not required for them. The operations were always regarded as sketchy and preliminary to exact survey. The survey establishments were not sufficiently large to undertake much survey work on an adequate scale for general administrative purposes, in one province, without putting a stop to the preliminary survey work in all other provinces. Thus the so-called

topographical surveys of those days were in reality geographical reconnaissances, sufficient for all the requirements of the Indian Atlas and for general reproduction on small scales, but not for purposes which demand accurate delineation of minute detail. Necessarily, therefore, calls are now being made from various quarters for new maps and new surveys; and not unfrequently complaints are made of the old surveys, that they are inaccurate and inadequate for present requirements. As a matter of fact, however, they are as good as they were intended to be, or could have been made without being far more costly. Their cost rates per square mile do not generally exceed a tenth of the average cost rates of surveys showing the topographical details with all the fulness and accuracy that are now required for local administrative purposes. They have had their day, and have been of much utility hitherto; but the time has arrived when they must be superseded by more elaborate survey operations.

18. The general out-turn of topography executed during the year in the course of the operations described in sections II to XIII, XIX, XXI, and XXIII of this report, excluding Forest Survey, has been as follows:—

6,431	square miles surveyed on the		4-inch	scale.
9,081	„	„	1	„
8,627	„	„	2	„
14	„	„	6	„
33	„	„	16	„

Four towns and one cantonment, embracing an area of 46 square miles, have been surveyed, on scales varying from 6 to 80 inches to the mile.

MOUZAWAR, RIVERAIN, AND FOREST SURVEYS.

19. The Mouzawar or Village Survey on the 4-inch scale of the Dera Ismail Khan district has been completed, and a similar survey has been extended into the Thal portion of the adjoining district of Muzaffargarh, where there had only been a Topographical Survey when the other parts of the district were surveyed village by village in 1856-57.

20. The Riverain Survey, on the 4-inch scale, on the Jumna river, which has been carried on for some years in connection with topographical operations in the Meerut Division, has been continued, and a similar Riverain Survey has been commenced on the Ganges river in connection with the same operations. A new Riverain Survey has been commenced by the Cadastral Survey Party employed in districts Ghazipur and Ballia of the North-West Provinces, which party has extended its operations across the Ganges to survey, on the 4-inch scale, the village lands of district Shahabad of Bengal, lying opposite to district Ghazipur.

21. The Punjab Revenue Survey Party has continued, for forest purposes, the 4-inch survey of the Kala Chitta Range in the Rawalpindi District, which work has been completed. The survey party in the Konkan, which has hitherto been employed in surveying on the 2-inch scale solely for topographical purposes, has been engaged in surveying the Thana District on the increased scale of 4 inches to a mile, to meet the requirements of the Forest Department. The area usually accomplished by the party has consequently been diminished, there being a difference in out-turn between the past and present seasons of 670 square miles. In British Burma a small area of very difficult country, forming part of one of the forest reserves in the Tharawaddy District, has been surveyed on the 4-inch scale.

22. The survey of the Dang Forests of the Khandesh District on the 4-inch scale, undertaken for the Forest Department, has been continued by the Guzerat Topographical Survey Party. The areas of all these operations are—

Mouzawar	...	...	1,687	square	miles.
Riverain	...	...	199	„	„
Forest	...	...	1,311	„	„

CADASTRAL SURVEYS.

23. In the North-West Provinces the Cadastral Survey of district Ghazipur has been completed, and cadastral operations have been continued in districts Ballia and Mirzapur, also in certain villages of the Tarai

District. An experimental measure has been introduced at the request of the Board of Revenue, North-West Provinces, in connection with the Cadastral Survey of Mirzapur, of having the *khasras* (giving particulars of the occupancy and ownership of village lands) written by the surveyors at the time of the survey of the fields. The experiment, which is expected to bring about a large reduction in the usual expense of the preparation of the "Record of Rights," cannot be considered to be complete until the duties of the Settlement Officer in connection with the Record of Rights have been carried out during next season.

24. In British Burma, districts Hanthawaddy, Bassein, and Tharawaddy have continued to occupy the three cadastral parties at work in the province, and the Hanthawaddy party has also carried on the survey of the Rangoon Town District.

The Hanthawaddy party has again sent a detachment to Arakan to continue the skeleton survey of boundaries of waste land grants.

In Assam a small party, specially organized, has been engaged on the Cadastral Survey of selected villages in three parts of district Sylhet, as a test on the accuracy of the *mahalwar* maps of the district, which were constructed by a civil establishment in 1862. The areas surveyed cadastrally are—

North-West Provinces	...	...	...	1,385 square miles.
British Burma	...	...	...	3,513 „ „
Assam (Sylhet)	...	...	...	26 „ „

25. In British Burma the officers of the Cadastral Survey Parties have continued to hold in view the wishes of the local administration regarding the training of Burmans as field surveyors; but the reports concerning the value of the work of these men are not so favourable as last year. Though doing work generally good in quality, the Burmans are said to be very inferior to the Hindustani surveyors in rapidity of execution, most of them working only in a half-hearted way, and serving with the survey parties solely with the object of qualifying for better civil appointments. The dislike of the Burmans to remain long with the survey parties arises partly from the circumstance that the employment offered to them as field surveyors extends only over six months, without, as a rule, any leave allowances being granted to them during the other half of the year. There is also the disadvantage in the employment that service as a "field surveyor" is only temporary service, non-qualifying for pension.

26. The field surveyors of the Indian Cadastral Surveys labour under the same disadvantage of having their service regarded as only "temporary," having in this respect succeeded to the status of the settlement "amins," whose duties they have assumed, and being quite distinct, as regards the conditions of service, from the sub-surveyors (trained as topographers and theodolite surveyors) of the permanent establishments, whose service qualifies for pension. The present "field surveyors" are much more highly trained than the old "amins," and many of them have served continuously, and in several districts, since the commencement of cadastral operations in the North-West Provinces. The men are deserving of having their status improved; and in the interests of Government it is desirable that they should be permanently attached to Cadastral Survey Parties, and their service made "permanent," if cadastral operations are in future, as now, to form a considerable part of the regular duties of the Survey Department.

27. Towards the close of the year an important Resolution—No. 458, dated 4th September 1882—was issued by the Government of India in the Revenue and Agricultural Department, drawing the attention of the Local Governments marginally specified to the unequal cost of revenue surveys undertaken in different provinces or districts, as well as to the inconvenience and expenditure caused by the absence of a definite understanding between the survey and the revenue officers as to the extent and character of the work which one department requires from the other. A question was raised as to the comparative cost of cadastral surveys executed by the Survey Department and those executed by the Revenue Settlement Department. It was stated that

North-Western Provinces.
British Burma.
Bengal.
Punjab.
Central Provinces.
Assam.

whereas the accuracy of the professional maps never fell below a certain fixed standard, on the contrary under non-professional management the work turned out was very unequal, and many of the maps had proved comparatively useless. Enquiries have led the Government to suppose that the cost of the latter is not at the present time much below that of the former, more particularly in the North-West Provinces, where a considerable decrease in the rate of expenditure has been effected by modifications of procedure, the officers of both the Survey and Settlement Departments having co-operated in reducing the system of cadastral survey to a more efficient and economical standard than that which had formerly prevailed. A further question was raised as to the extent to which the work of the survey parties employed upon topographical surveys can be utilized for cadastral purposes, or whether, on the other hand, maps which have been supplied by non-professional cadastral parties can be utilized for topographical purposes. The system which should be adopted in future cadastral surveys is considered; it is remarked that there is a general consensus of opinion that a skeleton survey, conducted under professional agency, should precede all field plotting, by whatever agency performed; the skeleton is expected to contain all the tri-junction pillars in the boundaries of villages, and a series of intermediate pillars at distances of somewhat less than half a mile apart; the field plotting, when not filled in professionally, to be undertaken by the village *patwaris* or accountants. Local Governments are at liberty to employ other than professional agency when they please, provided the agency employed is thoroughly trained for the purpose. Suggestions are made regarding the training of *patwaris*, the formation of survey schools, and the system of mensuration to be taught. The inconvenience of irregular demands on the Survey Department, which involve sometimes the formation of untrained survey parties, at other times the breaking up of well-trained parties, is prominently noticed; and Local Governments are requested to cause forecasts to be made of the areas which will have to be surveyed during the next ten years, and so to arrange their programmes that work may be found without interruption during that term for the entire staff which is placed in charge of the initial operations. As regards locally organized surveys, the cost must be kept within certain limits, a system of survey must be adopted which will ensure the quality being kept up to a certain standard, and the cost and quality must be tested by recognized experts.

GEOGRAPHICAL RECONNAISSANCE.

28. The geographical surveys and reconnaissances described in sections VIII, XIV, XXIII, XXIV, XXVI, and XXVII have resulted in an addition to the country already mapped as follows:—

Burma and Manipur boundary	...	...	1,600	square miles, $\frac{1}{2}$-inch scale.
Ditto	...	...	1,150	„ $\frac{1}{4}$ „
Kohat frontier	...	...	450	„ $\frac{1}{2}$ „
Beluchistan	...	...	3,240	„ $\frac{1}{2}$ „
Ditto	...	...	2,420	„ $\frac{1}{4}$ „
East Sikkim	...	...	180	„ $\frac{1}{2}$ „
Nepal	...	...	720	„ $\frac{1}{4}$ „
Tibet	...	...	690	„ $\frac{1}{2}$ „
Dardistan	...	...	200	„ $\frac{1}{4}$ „
Kishanganga	...	...	600	„ $\frac{1}{4}$ „

TRANS-HIMALAYAN GEOGRAPHICAL EXPLORATIONS.

29. The celebrated explorer Pundit Nain Singh, C.I.E., who was originally trained by the late Col. T. G. Montgomerie, R.E., for Trans-Himalayan survey operations, and whose services are well known not only to the Government of India, but to all who take an interest in the geography of Central Asia, died on the 24th January 1882. He had received honorary distinctions from the Royal and other Geographical Societies in Europe, had been made a Companion of the Indian Empire and been given a grant of land in perpetuity for himself and his heirs by the Government of India in acknowledgment of his services. And these services were not restricted to the several years when he was actually making explorations; but after he retired from active duties he was occasionally employed in training other natives of India for similar explorations, and in imparting to them something of the knowledge and skill which he had himself acquired in the course of his long and varied experiences. Very

intelligent and most trustworthy, his name will always hold an honourable place in the annals of the Indian Survey Department.

30. The present report contains a map and brief accounts of route surveys in the regions to the west and north of the frontiers of Sikkim, which were made in 1879 by an employé of the Educational Department of Bengal, and during 1880-81 by an employé of this department, which have recently been worked out and mapped by Captain Harman.

Also a map and a short account of route surveys in and beyond Badakshán, in Roshán, Shignán, and other districts bordering the Panjah river and the collateral affluents of the river Oxus, which were made during the years 1878 to 1881 by M— S—, an employé of this department, and which contribute much matter towards the filling in of the numerous lacunæ in the existing maps of this region.

Also a preliminary account of explorations over an extensive area in Great Tibet, to the north and east of the regions reached by Pundit Nain Singh, which were made by his pupil and once companion, A—k, who has returned to India, after an absence of four years, so recently that as yet there has not been time to reduce his observations, translate his journals, and construct a map in illustration.

31. At the International Geographical Congress and Exhibition which was held at Venice in the autumn of 1881, two medals were placed at the disposal of the Surveyor-General for award to the two native explorers whom he considered most meritorious. One of these has been presented to M—S—; the other is reserved for presentation to A—k, in the expectation that when his route surveys are worked out he will be found to be fully deserving of the honour.

PART I.

THE OPERATIONS OF THE SEVERAL SURVEY PARTIES APPERTAINING TO THE THREE BRANCHES OF THE SURVEY DEPARTMENT.

TRIANGULATION AND COLLATERAL OPERATIONS.

I.—THE EASTERN FRONTIER SERIES.

32. The programme of operations for the field season embraced the following projects:—

(A) The connection of the principal triangulation with the base-line of verification in Mergui, which had been selected and marked out during the previous field season, as intimated in the report for last year.

(B) The extension of the principal triangulation down the coast line and the islands of the Mergui Archipelago, as far as might be practicable during the time available.

(C) The preparation and measurement of the base-line in Mergui, and its connection with the mean-sea level.

(D) Astronomical determinations of latitude and azimuth at the stations of the principal triangulation in the neighbourhood of the base-line.

33. The experience gained in previous years had shown that suitable atmospheric conditions for the observation of distant objects were only to be expected during the first half of the field season. By the middle of the month of January dense haze usually sets in, which shuts all distant objects out of view, and this of course necessitates the suspension of the measurement of the angles of triangles of which the sides usually range from 10 to 40 miles in length. It was therefore determined to devote the first half of the field season to the principal triangulation, and the remainder to the measurement of the base-line, the astronomical observations being taken whenever convenient. With a view to expedite the progress of the triangulation and make the most of the limited period of favourable atmosphere, the Government steamer *Celerity* was placed for a few months at the disposal of this department, in order that the survey officers might no longer be dependent—as they had been in previous years—on the sailing vessels ordinarily used by the native sea-faring population in their coasting voyages, and the employment of which had been a constant source of delay and inconvenience. The steam-launch *Moulmein* was also lent for a short time by the Chief Commissioner in British Burma, and was found most serviceable.

34. Two triangulation parties were available for the operations, viz. the Eastern Frontier Party, recently under Captain Hill, but now under Major Rogers; and the party under Colonel Branfill, which in the previous year had been employed in completing the Eastern Sind Series. During the first half of the season these parties worked independently of each other,—Colonel Branfill's in connecting the principal triangulation with the base-line and executing the necessary preliminaries for the linear measurement; Major Rogers', in extending the principal triangulation southwards. They then assembled at the base and measured it with the Colby apparatus of compensation bars and microscopes—used in conjunction with the standard of length of this survey—which has been employed since the year 1830 in measuring all base-lines for the principal triangulation, and is mentioned in paragraph 6 of this report. Colonel Branfill supervised and took a share in both the measurement of the base-line and the collateral triangulation and astronomical observations.

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, January 1883

35. The principal triangulations were completed by the middle of January; the work executed by both parties fixes 15 new stations, and gives as many new triangles; it extends over a direct distance of 109 miles between the parallels of 10° and 12°, and includes an area of 1,688 square miles. Eight new stations were fixed in connecting with the base-line, and seven on the extension. But whereas the former are comprised within a distance of 15 and an area of 21 square miles, the latter extend over a distance of 94 miles and embrace an area of 1,667 square miles. Major Rogers made a reconnaissance of the islands of the Mergui Archipelago with a view to the future secondary triangulation to Singapore, down to the parallel of 9° 20′, a distance of about 60 miles beyond the southernmost side of the principal triangulation. Forty-eight prominent points on the Malayan Peninsula and the islands of the Archipelago were fixed by both parties, by observations taken at the principal stations; they lie in an area of 3,344 square miles exterior to that of the principal triangulation. Thus the entire area operated in was about 5,000 square miles.

36. Great advantage was derived from the employment of steamers instead of sailing vessels, in enabling the survey officers and the parties of signallers to be moved about with rapidity; for the observing season proved to be a very short one—barely two months—between the cessation of the rains in November and the setting in of the haze in January. The steam-launch *Moulmein* proved to be an invaluable auxiliary to the steamer *Celerity*, in affording access to points on the coasts and islands which the larger vessel could not have reached because of the shallowness of the water. By means of heliographic signals on the Morse system—between himself, the officers of the steamer, and his assistants—Major Rogers directed the general movements, and was thus able to make the most of the steam power at his disposal. Captain Hotham, of the Indian Marine Department, commanded the *Celerity*, with the crew of which the steam-launch was also worked. His services, and those of his subordinate officers, are warmly acknowledged by Major Rogers; for they all took a keen interest in the operations, and Captain Hotham has expressed a wish to be again employed in co-operation with our officers whenever the triangulation is extended to the south.

37. By the end of January all hands were engaged on the measurement of the Mergui base-line under Colonel Branfill. This base is about 3·4 miles in length, or somewhat less than half the average length of all the base-lines previously measured in India with the Colby apparatus, with the exception of the Cape Comorin base, which is only 1·7 miles in length; but the Cape Comorin base was measured four times, with a view to the investigation of the probable error of base-lines measured with the Colby apparatus, whereas the longer bases were only measured once. The shorter a base the greater the number of triangles that are required to connect it with the principal triangulation, and *vice versâ*. In the operations of this Survey the length has generally been regulated with a view to employing the measuring parties during the whole of the field season, in order to avoid the loss of time which would be entailed by transferring them to other operations in other, and probably distant, localities during the most favourable season of the year for field work. But suitably level ground for the measurement of a longer base could not be found anywhere on the coasts or the islands of the Mergui Archipelago, whereas there was ample employment for the survey parties in the neighbourhood, in addition to the measurement of the base. Thus a base of short length was not only obligatory, but the most convenient in the present instance.

38. The actual measurement of the base and the comparisons of the compensation bars with the standard of length occupied only 24 days. This, of course, is exclusive of the time spent in various preparations on the spot, which were all more or less tedious. The apparatus had been put into thorough working order, under the supervision of Mr. Hennessey, before it was despatched from the head-quarters of the Trigonometrical Survey in Dehra Dún, and it reached Mergui in good order, having met with no mishap on its long journeys by land and sea; thus the measurement of the base was performed with rapidity, and without let or hindrance of any kind. At several, but not all, previous base-lines it has been customary to divide the line into sections connected by triangulation, in order to test the

operations by comparing the ratios of the measured lengths of the sections with the values of ratio afforded by the triangulation, and also to guard against accidental gross error in the record of the number of sets measured from day to day; but the measured length was found to agree so closely with the value brought down through the principal triangulation, that it was certain that no material errors could have been made; and the evidence afforded by the tests applied on previous occasions—and more particularly by the four-times measured base at Cape Comorin—have sufficed to establish the great accuracy and precision of the apparatus, and to show that further triangulation tests are unnecessary. Consequently, though in the present instance the base-line was divided into two sections, with a view to enabling comparisons of the measuring bars with the standards of length to be made at the centre as well as at the two extremities, the sections were not connected by triangulation, as no advantage, commensurate with the labour of measuring three additional principal triangles, would have been gained; the time this would have occupied was more profitably spent in astronomical observations for latitude and azimuth. With a view to determining the height of the base-line above the sea, a line of spirit levels was carried between one end of the base and a point on the coast, at which a tidal station will hereafter be established.

39. The value of the length of the base-line, as determined by calculation through the triangulation from the side of origin of the Eastern Frontier Series, is in excess of the measured value by about 3·4 inches, or 1 inch per mile; the triangulation consists of a chain of polygonal figures—mostly hexagons and quadrilaterals—of which the length is nearly 1,000 miles, while the number of triangles on the shortest line between the side of origin and the base-line is 108. Thus the closing error on the base is, for so long a chain, a small one; it is less than the theoretical probable error of the triangulation calculated on the assumption that the probable errors of the angles do not exceed 0·5″: it indicates that the error generated in the measurement of the angles of the principal triangles may be safely considered to have been very minute.

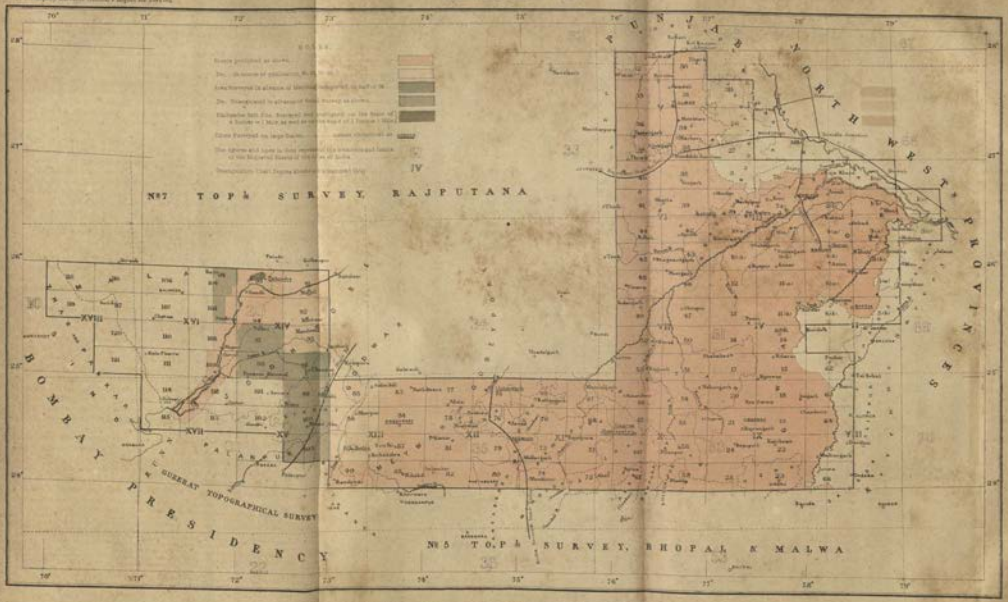
40. Astronomical observations for the determination of the latitude and the azimuth were taken at four of the stations of the principal triangulation in the vicinity of the Mergui base-line. It is well known that all such determinations are liable to be influenced by local deflections of the plumb-line; consequently it is always preferable to obtain fairly accurate results at several points than seemingly very accurate results at a single point, for the magnitude of the latent error due to the local deflections frequently exceeds the probable errors arising from all other causes put together. In the present instance all the astronomical stations lie within an area of about 20 square miles; and the differences between the observed and the geodetically computed latitude and azimuth at each station show that there can be no material variations of local attraction within this area. The mean geodetic latitude has been found to be 8·2″ in defect of the mean astronomical latitude, while the mean geodetic azimuth is 11·2″ in excess of the mean astronomical azimuth. The geodetic calculations have been brought up from Kalianpur—Colonel Everest's station of astronomical origin, referred to in paragraph 7—through the triangulation of the two Longitudinal Series west and east of Calcutta, and through that of the Eastern Frontier Series; and they are based on Colonel Everest's elements of the figure of the earth, which have invariably been used in all the calculations of this Survey up to the present time. Later and more accurate elements were calculated by Colonel Clarke, C.B., of the Ordnance Survey, in 1866; if they were employed, the difference in latitude would be reduced to about 6″, and that in azimuth to 8″. These quantities may therefore be taken to represent the magnitudes of the discrepancies arising from the combined action of the errors of the triangulation connecting the astronomical origin at Kalianpur with the astronomical terminus at Mergui, and the errors due to the local attractions at the two localities; the heoretical probable errors of the triangulation are less than $\pm 1''$ in latitude and $\pm 3''$ in azimuth; thus, the discrepancies are probably mainly due to the influence of local attractions in deflecting the plumb-line at the initial and terminal astronomical stations.

No. 1 PARTY.

INDEX TO THE SHEETS OF THE GWALIOR & CENTRAL INDIA TOPOGRAPHICAL SURVEY.

On the Scale of 1 Inch. = 1 Mile.

To accompany Surveyor General's Report for 1881-82.



41. Latitude determinations were also made at Moulmein by Major Rogers and his assistants at the end of the field season. The observations were taken at three stations, situated within an area of seven square miles. Here, in latitude 16° 29′, the mean geodetic value was found to be 6·5″ in defect of the mean astronomical value, as compared with 8·2″ at Mergui, in latitude 12° 23′. The zenith distances of the stars under observation were measured on the 18-inch vertical circle of an old two-foot theodolite, of inferior accuracy to the one employed by Colonel Branfill; but the difference between the results is probably mainly due to differences in the local attractions at Moulmein and Mergui.*

42. At the end of the field season Major Rogers made inspections of the working of the tide-gauges at Moulmein, Amherst, Rangoon, Elephant Point, and Port Blair, and then proceeded to Poona to relieve Major Hill of the charge of the Tidal and Leveling Party. The latter officer resumed charge of the Eastern Frontier Party, but a few weeks subsequently was transferred to the charge of the Deccan Topographical Party, on the death of Major Lees Smith. Thus the supervision of the recess duties generally—and more particularly the calculations for the reductions of the principal triangulation and the astronomical observations—mainly devolved on Colonel Branfill, who, having brought all the work to a satisfactory completion and handed it over to Mr. Hennessey for final disposal in the Computing Office at the head-quarters of the Trigonometrical Survey in Dehra Dún, proceeded to Europe on furlough for two years. The parties employed in the operations which have now been described have been broken up; most of the officers have been transferred to Topographical Surveys; the Native establishments have been reduced and transferred to the new Secondary Triangulation Party and the Nepal Boundary Survey.

II.—GWALIOR AND CENTRAL INDIA SURVEY (No. 1 TOPOGRAPHICAL PARTY).

43. The triangulation carried on by this party during this season lay mainly in the Native State of Sirohee, but also included small portions of Pálanpur and Dántá, the well-known hill station of Mount Ábu, falling about the centre of the triangulated part. The area thus prepared for future survey was about 1,620 square miles, all of which was more or less bad and difficult country.

Personnel.

Major C. Strahan, R.E., Officiating Deputy Superintendent, 2nd grade, in charge.
Mr. W. J. Cornelius, Assistant Surveyor, 1st grade.
„ P. J. W. Doran „ „ 1st „
„ C. T. Templeton „ „ 2nd „
„ A. Kitchen „ „ 2nd „
„ G. P. Tate „ „ 3rd „
Sub-Surveyor Abdul Gufar.
„ Abdul Aziz.
„ Ahmad Sayid.
„ Jafir Ali.
„ Abdul Rahman.
„ Mr. J. R. Harris.

44. The country surveyed in detail on the scale of 1 inch = 1 mile lay in the three Rajput States of Marwar (Jodhpore), Mewar (Oodeypore), and Sirohee, embracing an area of 2,440 square miles, of which Major Strahan reports that 460 square miles were about as difficult and intricate as could well be found, whilst the remainder was singularly easy to delineate. The portions completed during the season are represented on the index map as part of sheet 85 (the difficult ground mentioned above) and sheets 91, 92, 95, and part of 96.

45. The programme of operations for the field season was somewhat interfered with, as Major Strahan had to pass a military examination, which necessitated his withdrawal for several weeks from the field operations to a military cantonment. He might have claimed to be relieved of all survey duty during this period, but being aware that no officer was readily available to take his place he did not take the leave to which he was entitled, but continued to

* Colonel Branfill reports of Lieutenant the Hon'ble M. G. Talbot, R.E., who was attached to his party with a view to being instructed in the geodetic operations of this Survey, that he took an equal share with him in the principal triangulation and astronomical observations, and has shown himself to be "an excellent observer, with very keen eye-sight and delicacy of manipulation:" he was also of much assistance at the base-line. Mr. D. Atkinson executed the spirit-levels, connecting the base-line with the sea, conjointly with Mr. Senior. Mr. Pocock built three of the principal stations, one being 1,500 and another 2,000 feet above the level of the sea, and cleared the hill-tops of forest. Mr. Potter built and cleared three stations, one, Kisseraing, on a large island surrounded by mangrove swamps, to reach which it was necessary to open out a road more than five miles in length for the passage of the large theodolite. Mr. Torrens was employed on similar operations, and on secondary triangulation in Mergui. Each officer shared in the measurement of the base-line. Subsequently Messrs. Pocock and Potter took most of the star observations for the latitude determinations at Moulmein. Including Moung Shoay Gyoke, the Burmese sub-surveyor, all are reported by either Colonel Branfill or Major Rogers to have worked remarkably well and given entire satisfaction.

exercise general superintendence over the survey operations while preparing himself for the military examinations.

46. As the No. 7 Topographical Party has recently been transferred from Rajputana to Burma, the uncompleted portion of the ground which had originally been allotted to it for survey has been handed over to No. 1 Party to complete, which will in future be designated the "Central India and Rajputana Survey Party." The extent of area which it has to complete is about 22,500 square miles; of this area the greater part, being desert country, will be surveyed on the half-inch to the mile scale.

47. During the ensuing season this party will extend the triangulation over sheets Nos. 101 and 102, and will complete the detail survey of sheet 99 and the remaining part of sheet 96 in addition to part of the country to the north, which has been previously triangulated by No. 7 Party.*

III.—KHANDESH AND BOMBAY NATIVE STATES SURVEY (No. 2 TOPOGRAPHICAL PARTY).

48. This party continued the survey of the Khandesh district as in previous seasons, the field survey being made on the scale of 2 inches = 1 mile, and the maps published on the scale of 1 inch = 1 mile. An area of 490 square miles of country was triangulated during the season; and in addition 1,025 linear miles of traverse were completed, fixing 1,034 village boundary tri-junction pillars. This completes the preparation for detail survey of the country remaining to this party.

Personnel.

Major T. T. Carter, R.E, Deputy Superintendent, 2nd grade, in charge.
Mr. A. G. Wyatt, Surveyor, 4th grade.
„ J. A. Barker, Assistant „ 1st „
„ F. E. Warde „ „ 1st „
„ G. G. Vander-Beck „ „ 2nd „
„ E. Graham „ „ 2nd „
„ C. George „ „ 3rd „
Sub-Surveyor Sheikh Omer.
„ „ Mr. F. Rozario.
„ „ Hyder Ali,
and five others.

49. The topography completed during the season covered an area of 1,554 square miles. Of this, upwards of 1,060 square miles was cultivated country. This area is represented on the index map as sheets 21, 23, 24, and part of sheet 34, and is situated in the undermentioned talukas:—

	Square mile.
Amalner	260
Erandol	258
Páchora	450
Chálisgaon	228
Nandurbár	260
Nasirabad	5
Dhulia	9
Pimpalner	3
Nizam's territory ...	81

The country in sheet 34, Major Carter reports as being very unhealthy; it being impossible to send surveyors into it before the beginning of April. It is chiefly forest land inhabited by Bhils. They attribute the unhealthiness of their district to the water absorbing poisonous qualities from the roots of certain shrubs. Even in April and May the parties have to be numerically stronger than usual to fill the places of men suffering from fever.

50. It is expected that during the ensuing field season the remainder of the country allotted to this party will be finally surveyed. Arrangements have therefore been made for this party to take over the portions of Malwa that have not as yet been surveyed by No. 5 Topographical Party, which is about to be transferred to Mirzapur.†

* Major Strahan reports that "Mr. Doran's work for the season was entirely to my satisfaction." Messrs. Templeton, Kitchen, and Tate are commended for their accuracy. Of the sub-surveyors, Abdul Gufar is more especially noticed for his care and accuracy.

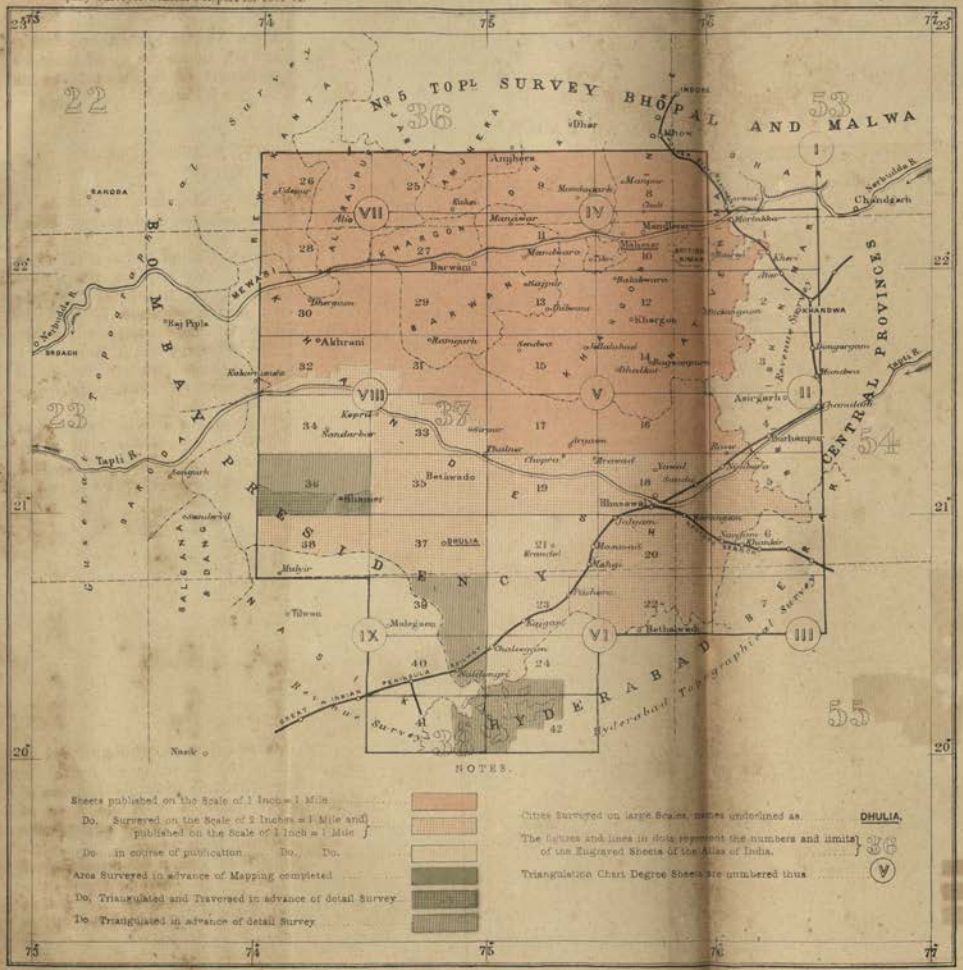
† Major Carter reports that Messrs. Wyatt, Graham, and George, and Sub-Surveyors Sheik Omar, Mr. Rozario, and Hyder Ali, "are particularly deserving of mention" for their good work.

No. 2 PARTY.

INDEX TO THE SHEETS OF THE KHANDESH & BOMBAY NATIVE STATES TOPOGRAPHICAL SURVEY,

On the Scales of 1 Inch = 1 Mile and 2 Inches = 1 Mile.

To accompany Surveyor General's Report for 1881-82.



NOTES.

Sheets published on the Scale of 1 Inch = 1 Mile

Do. Surveyed on the Scale of 2 Inches = 1 Mile and published on the Scale of 1 Inch = 1 Mile

Do. in course of publication Do. Do.

Area Surveyed in advance of Mapping completed

Do. Triangulated and Traversed in advance of detail Survey

Do. Triangulated in advance of detail Survey

Cities Surveyed on large Scales, names underlined as DHULIA.

The figures and lines in dots represent the numbers and limits of the Engraved Sheets of the Atlas of India. 36

Triangulation Chart Degree Sheets are numbered thus (V)

Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India, at the Surveyor General's Office, Calcutta, November 1883.

No. 5 PARTY.

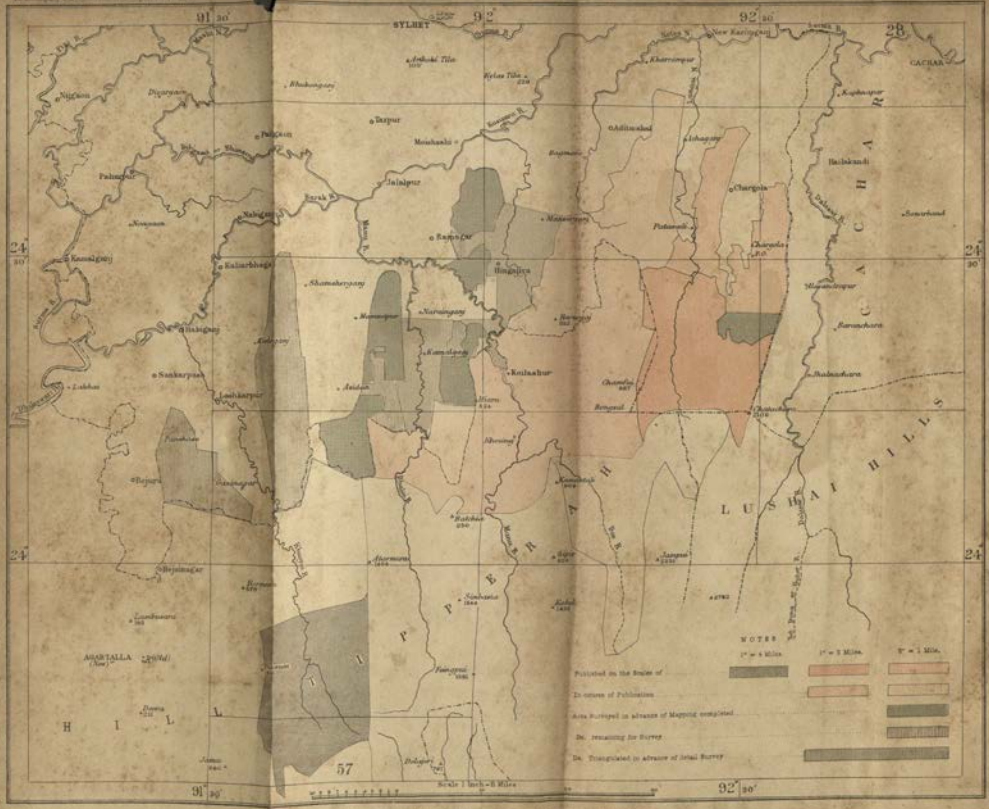
INDEX TO THE SHEETS OF THE BHOPAL & MALWA TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile.

To accompany Surveyor General's Report, 1881-82.

Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India, at the Surveyor General's Office, Calcutta, January 1883.

INDEX TO THE SURVEY OF SOUTH SYLHET AND TIPPERAH HILLS.

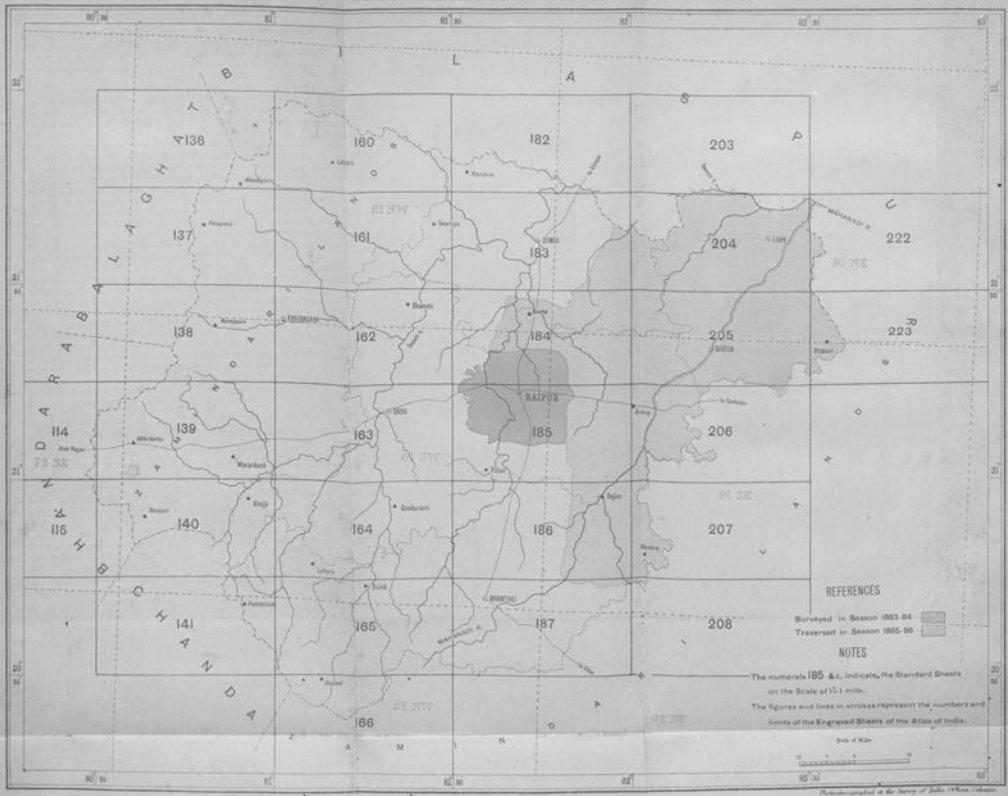


Published under the direction of Lieut.-General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India, at the Surveyor General's Office, Calcutta, November 1875.

CENTRAL PROVINCES SURVEY.

INDEX TO THE SURVEY OPERATIONS IN DISTRICT RAIPUR.

No. 3 REV. PARTY



Published under the direction of Lieut. Colonel H. H. Thuillier, R.E., Officiating Surveyor General of India,
Survey of India Office, Calcutta, January 1887.

Photozincographed at the Survey of India Office, Calcutta.

IV.—BHOPALAND MALWA SURVEY (No. 5 TOPOGRAPHICAL PARTY).

51. The work of this party during the season under review was in continuation of that previously carried on—a topographical survey on the scale of 1 inch=1 mile of the Native States of Central India. The country surveyed during the season fell chiefly in the territories of Bánswára, Oodeypore, Partábgarh, and Dúngarpur. With the exception of about 190 square miles of country, which being in the table-land of Central India was open, well-cultivated country, the whole area surveyed in detail consisted of very hilly, jungly, intricate country. A considerable portion of the Mahi river fell within the season's work. The total area surveyed in detail was 1,096 square miles.

Personnel.

Major J. R. Wilmer, S C., Deputy Superintendent 4th grade, in charge.
Mr. C. F. Hamer, Surveyor, 4th grade.
„ E. A. Wainright, Assistant Surveyor, 1st grade.
„ H. T. Kitchen „ „ 1st „
„ W. H. Lilley „ „ 1st „
„ G. R. Copping „ „ 1st „
Sub-Surveyor Prem Raj.
„ Harlal Sing.
„ Kristo Dhan Chatterjee.
„ Gobardhan Dass.
„ Shiv Charan.

52. The triangulation completed during the season covered about 1,096 square miles. In addition to the topography on the standard scale, the cities of Bánswára and Jaora were surveyed on the scale of 6 inches = 1 mile. The party is reported to have suffered considerably from fever during the field season.

53. During the ensuing season a portion of the party will be employed in completing the topography of sheet 49, for which the requisite basis of triangulation has already been prepared. The bulk of the party will, however, be transferred from a Native State to British district, Mirzapur, with a view to completing the topography which is required in connection with the cadastral survey operations now in progress in that district. The completion of the survey of Malwa has been allotted to No. 2 Topographical Party.*

V.—SYLHET, KHASI, AND GARO HILLS SURVEY (No. 6 TOPOGRAPHICAL PARTY).

54. This party took the field early in December to carry on, at the particular request of the Chief Commissioner of Assam, the work previously commenced, of surveying the lands in South Sylhet, which, owing to their being waste, hilly ground, had been left unmapped by the revenue survey of that district. These lands are now being rapidly taken up for the cultivation of tea.

Personnel.

Bt. Lieutenant-Colonel R. G. Woodthorpe, R.E., Assistant Superintendent, 1st grade, in charge.
Mr. A. Channell, Surveyor, 4th grade.
„ J. McCay, Assistant Surveyor, 2nd grade.
„ J. Keating „ „ 3rd „
„ D. Campbell „ „ 3rd „
„ A. Ewing „ „ 3rd „
Sub-Surveyor Shah Nusiruddin.
„ Faida Ali,
and nine others.

55. The country under survey consisted of the lower spurs of the Tipperah hills running northwards past the British boundary into the plains of South Sylhet, as well as the isolated group of low hills which lies between Fenchuganj and the Manu river. These tracts of country, hitherto described on the maps as "hills covered with impenetrable jungle," are rapidly becoming very valuable, as they are being taken up and opened out for tea cultivation. This survey is made on the scale of 2 inches equal to 1 mile, and during the season an area of 244 miles was completed. The boundaries of certain tea grants met with were also surveyed, a linear distance of 47 miles of traverse having been run in order to fix them.

56. In addition to the above, a portion of Hill Tipperah, covering an area of 222 square miles, was surveyed on the smaller scale of $\frac{1}{2}$ inch equal to 1 mile.

57. Lieutenant-Colonel Woodthorpe reports that the country is very difficult by reason of the dense bamboo and tree jungle with which all the low hills are covered, the work there being necessarily slow, as each small stream and its affluents have to be carefully traversed with compass (or plane-table) and chain, checks being made by cross lines and such independent fixings of

* Major Wilmer, after close personal inspection of the work of his assistants, commends Messrs. Hamer, Wainright, Kitchen, and Copping for the accuracy of their work, that of Messrs. Wainright and Kitchen being especially neat. Sub-Surveyor Prem Raj is also specially mentioned for good work.

position as can be obtained. The heavy storms so prevalent in March and April very much impeded, and finally put a stop to, the work at the end of the first week in April, after which work became impossible.

58. The programme of this party for the ensuing season is to continue the work westwards from where it was left off in the previous year, and it is hoped that the work in South Sylhet will be finished during the season.*

VI.—THE RAJPUTANA AND SIMLA SURVEYS (No. 7 TOPOGRAPHICAL PARTY).

59. This party, reduced in strength by the transfer of three European assistants, continued the survey of the Rajputana States, in accordance with the programme set forth in paragraph 59 of the General Report for last year.

Personnel.

Mr. G. A. McGill, Surveyor, 1st grade, officiating in charge.
Mr. J. H. Wilson, Assistant Surveyor, 1st grade.
„ G. L. Fleming „ „ 2nd „
Sub-Surveyor Madhu Sudan Dutt.
„ Kalka Persad.
„ Sher Shah.
„ Hossein Buksh,
and two apprentices.

The detail survey, which is executed on the scale of $\frac{1}{2}$ inch = 1 mile, was carried on mainly in that part of the Jodhpore State which is shown on the index map as degree sheet XX, a small portion of degree sheet XIX being also surveyed. An area of 5,611 square miles was completed.

60. The country met with in degree sheet XX is described as being "unquestionably the finest that this party has had to survey for the past five years." Here the usual rolling sand hills and ridges of the desert are replaced by extensive plains composed of sandy clay, all more or less fertile and varied by clumps of rocky hills.

61. The triangulation was continued during the season northwards over degree sheet XVIII, and the remaining portion of degree sheet XIX (*vide* index map), embracing an area of 3,500 square miles. Degree sheet XVIII is described by Mr. McGill as being the worst bit of desert ground he has seen, being almost devoid of villages, and water being exceedingly scarce, and, when met with, often poisonous. These troubles are fortunately in part compensated for by the extreme healthiness of the climate during the winter months.

62. This party has now been transferred to Burma, and will be merged into the Burma Topographical Party, the country remaining for survey being handed over to No. 1 Topographical Party for completion, as already stated in paragraph 46.†

VII.—THE MYSORE SURVEY (Nos. 8 & 9 TOPOGRAPHICAL PARTIES).

63. The operations of this survey during the year under review have been conducted by Major Thuillier, R.E., who resumed charge of the party on the 20th October 1881 after returning from furlough.

Personnel.

Major H. R. Thuillier, R.E., Deputy Superintendent, 1st grade, in charge.
Lieutenant F. B. Longe, R.E., Assistant Superintendent, 3rd grade.
Mr. E. S. P. Atkinson,* Surveyor, 3rd grade.
„ L. Pocock* „ 3rd „
„ A. J. James „ 3rd „
„ F. Kitchen, Assistant „ 1st „
„ W. Stotesbury „ „ 1st „
„ H. Todd „ „ 1st „
„ J. Kennedy „ „ 3rd „
„ J. A. Higgs „ „ 3rd „
and 10 native sub-surveyors.

* During the recess only.

64. The European establishment during the field season was reduced to six Surveyors and Assistant Surveyors. This was due to casualties from the effects of the malarious climate in the Western Ghâts, where the party had been employed during the two previous years, and which resulted in the death of the senior Surveyor, Mr. Chew, and necessitated the transfer of two of the Assistant Surveyors to other parties working in more healthy districts. It was found necessary therefore to modify the programme proposed in the last report.

* Lieutenant-Colonel Woodthorpe speaks in the highest terms of the work of Mr. Ogle, not only in Manipur, where he assisted Major Badgley, but also in the many difficult and dangerous undertakings in which he has been associated with Colonel Woodthorpe. Mr. Chennell and sub-surveyor Shah Nusiruddin are also mentioned as having specially distinguished themselves.

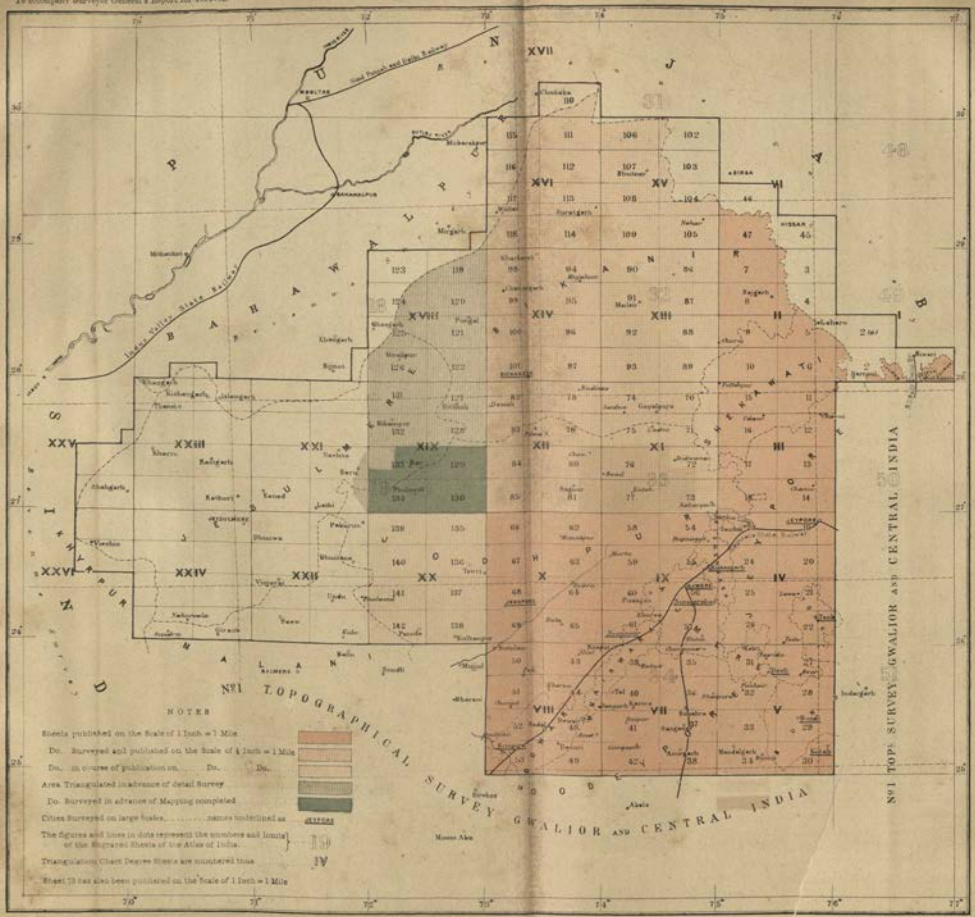
† Mr. McGill reports favourably of Messrs. Wilson and Fleming, and of his sub-surveyors, specially commending the cheerful and zealous manner in which they have conducted themselves.

No. 7 PARTY.

INDEX TO THE SHEETS OF THE RAJPUTANA TOPOGRAPHICAL SURVEY,

On the Scales of 1 Inch = 1 Mile and $\frac{1}{4}$ Inch = 1 Mile.

To accompany Surveyor General's Report for 1881-82.



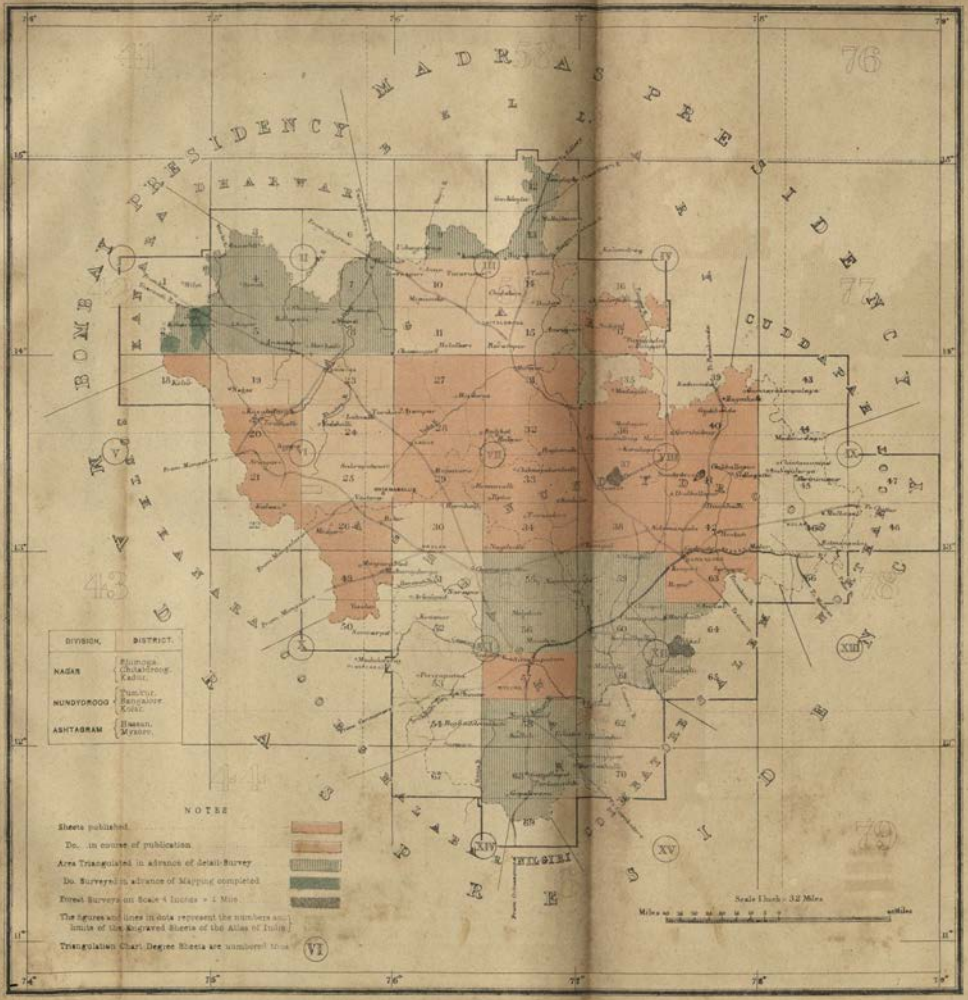
Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India, at the Surveyor General's Office, Calcutta, November 1881.

Nos. 8 & 9 PARTIES.

INDEX TO THE SHEETS OF THE MYSORE TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile.

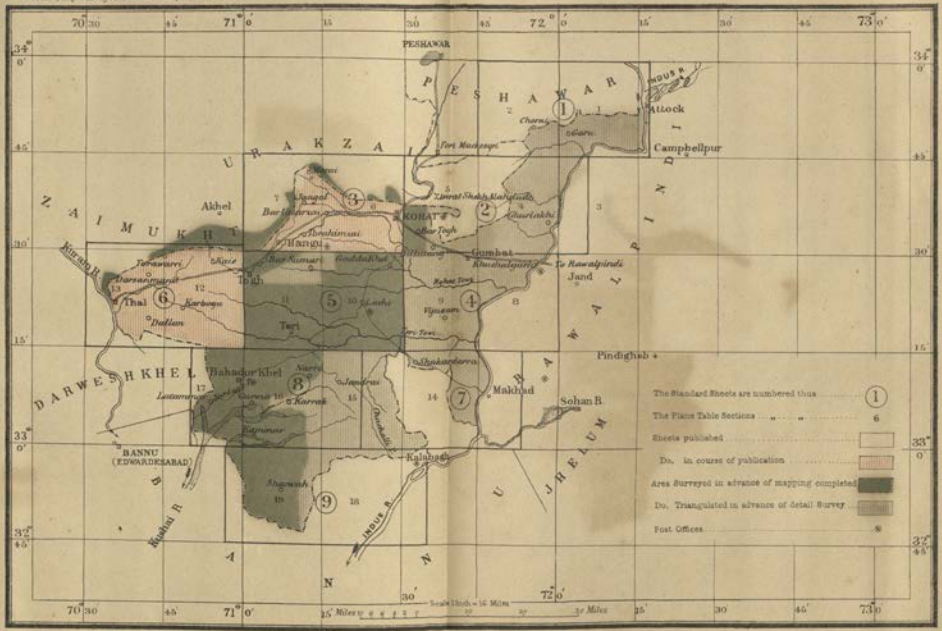
To accompany Surveyor General's Report for 1891-92



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S. Surveyor General of India,
at the Surveyor General's Office, Calcutta, November 1892.

INDEX TO THE SHEETS OF THE TOPOGRAPHICAL SURVEY, DISTRICT KOHAT.

To accompany Surveyor General's Report for 1881-82.



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India
Surveyor General's Office, Calcutta, October 1882.

65. As a large area of ground had been previously prepared for survey no further triangulation was required, and the operations were confined to topography. The districts in which the operations have been carried on during the year are Shimoga, Kadur, Hassan, and Chitaldroog; the two first being in the Malnád or highland region, and the others in the Maidan or open and undulating country.

66. The out-turn of detail survey on the scale of 1 inch = 1 mile embraces an area of 4,226 square miles, of which 1,460 square miles are in the Malnád and 2,766 square miles in the Maidan. In the former the work was exceedingly difficult, and the same obstacles to progress were met with as had been before encountered in the western parts of the province and previously described, the constant use of the chain being necessary. The work has been tested by 423 linear miles of check line and traverses, and was found to be accurately and carefully done. Numerous heights have been fixed, which will greatly increase the value of the final maps.

67. The results of this season's work will furnish material for the publication of standard sheets 10, 11, 14, 15, 19, 23, 24, 25, and 30. This very satisfactory out-turn of work, with its consequent low relative cost, Major Thuillier attributes in a great measure to the unusually good health enjoyed by the surveyors.

68. During the ensuing season the triangulation will be continued in degree sheets XI and XIV, the detail survey being carried on in sheets 1 to 9 inclusive, and sheets 12, 13, 55, and 56.*

VIII.—KOHAT DISTRICT SURVEY.

69. This party is engaged in making a standard topographical survey of the Kohat district on the scale of 1 inch=1 mile, and also in bringing up the final mapping of the surveys in Northern Afghanistan, which were executed during the late war. It took the field in December, weak both in European and Native Surveyors, and was subsequently still further weakened by casualties.

70. Major Holdich himself was not able to take the field on the 4th February, having to pass a military examination, which required him to reside for a time at a military station for the purpose of preparing for it.

Personnel.

Brevet-Major T. H Holdich, R.E., Deputy Superintendent, officiating 3rd grade, in charge.
Mr. T. E. M. Claudius, Surveyor, 4th grade.
„ W. W. McNair „ 4th „
„ R. F. Warwick, *Assistant „ 3rd „
Sub-Surveyor Esuf Sharif.
„ Imam Bux.*
„ Syad Ullah.
„ Hira Sing.
„ Atma Sing.
„ Kadar Sharif.*
„ Syad Mahbub.

* During the recess only.

71. The triangulation was carried on by two separate parties. Major Holdich took the north-east corner of the district, and triangulated that portion of country lying between Khushálgarh and Attock. He covered an area of about 500 square miles, and reports the country as generally very rugged, but not difficult for triangulation. The secondary triangulation of this district, which was executed some 30 years ago, was found of great assistance, and a large saving of time resulted from employing the points then fixed. Mr. McNair was employed in triangulating the country lying between Latammar and Bannu, which consists mainly of flat, open, sandy ground, its very flatness rendering it difficult to find and fix points by triangulation.

72. The country topographically surveyed consisted of the upper valleys of the Kohat and Teri rivers, the Surdag hills, and the Lawághar hills, with the low-lying plains at their foot on the west, bordering the Bannu district. A total area of 1,344 square miles was completed, a great portion of which was very intricate ground, requiring great care in delineation.

73. In addition to his other work, Mr. McNair fortunately succeeded in forming such friendly relations with one of the Waziri Chiefs that he was taken under tribal protection to make a reconnaissance of the tract of independent territory lying east of the Kurram river and immediately north of Bannu,

* Major Thuillier acknowledges the good services of Lieutenant Longe, R.E., and highly commends his energy and perseverance. He also reports very favourably on the work of all his European assistants, and of Sub-Surveyors Janki Dass Raghavyengar, Lachman Daji, and Balaji.

which is inhabited by the Daresh Khel Waziris, and embraces the well-known range of hills culminating in the Kafir Kot, which Mr. McNair is the first European to have visited. During the forthcoming season the topography will be continued, and probably completed in this district. A large scale plan of Kohat City will also be undertaken.

74. During the recess Major Holdich and his party were chiefly employed in constructing the final mapping of the surveys in Northern Afghanistan.*

IX.—THE GUZERAT TOPOGRAPHICAL SURVEY.

75. During the year under review the charge of this party has again devolved on Colonel Haig. Four descriptions of work have been carried on, viz.—

First, the ordinary topographical survey of Native States, executed on the scale of 2 inches = 1 mile, and published on the 1-inch scale.

Second, the preparation of a series of maps on the 2-inch scale, comprising British territory in detail and foreign territory in skeleton, and for the former utilising the maps of the Bombay revenue and settlement surveys as far as practicable

Third, the survey of the Dang Forests on the 4-inch scale.

Personnel.

Colonel C. T. Haig, R.E., Deputy Superintendent, 2nd grade, in charge.
Captain J. R. Hobday, S.C., Assistant Superintendent, 2nd grade.
Mr. A. D'Souza, Surveyor, 1st grade.
„ A. D L. Christie „ 4th „
„ C H. McAfee „ 4th „
„ C. Tapseli, Assistant „ 1st „
„ G. D. Cusson „ 1st „
„ S. F. Norman „ 3rd „
„ C A. Norman „ 3rd „
„ A. George „ 3rd „
„ H G. Ferns, Draftsman.
Sub-Surveyor Gopal Vishnu.
„ Lakshman Ghorpade.
„ Bhau Govind,
and 16 others.

Fourth, the survey of the city, cantonment, and environs of Surat on the scale of 12-inches = 1 mile.

76. The ordinary topographical work was carried on over an area of 1,287 square miles, contiguous to and in continuation of the area previously surveyed. It is territorially divided as under—

British ...	Surat Collectorate	296	square miles.
	Khandesh „	6	„
Foreign ...	Baroda State	796	„
	Pálanpur „	25	„
	Bánsda „	83	„
	Dharampur „	81	„

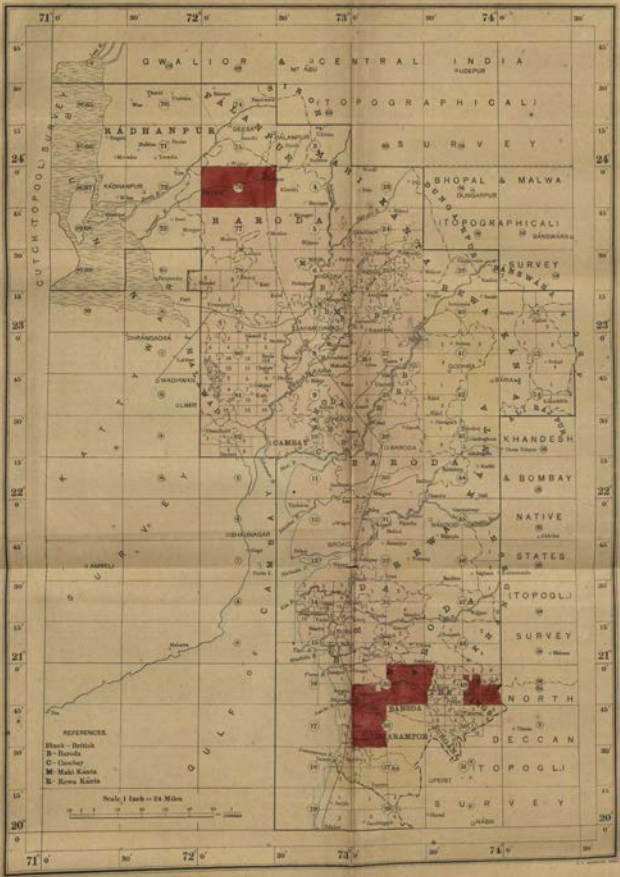
The ground surveyed is situated in four sheets, 76, 35, 36, and 37, two of which—76 to the north and 35 to the south—comprise the Native States, and have therefore been drawn on the 2-inch scale for reduction and publication on the 1-inch scale. Of sheet 36 only the western half has been surveyed; its publication must therefore lie over till the whole is complete. The country surveyed in the fourth sheet consists of irregular areas outlying the Dangs. When the large scale survey of the Dangs is reduced, this work will be incorporated with it, and the ordinary standard sheet on the scale of 1 inch = 1 mile, published.

77. An area of 152·3 square miles in the Dang Forests has been surveyed on the 4-inch scale, adding five sheets to this series of maps. Four-fifths of this area were surveyed on the contour system by means of water-levels, contours being drawn at vertical intervals of 25 feet. This work was done experimentally, and for the most part by Native surveyors, with a view to ascertaining whether the system might be introduced without any material increase of cost in supersession of the long-established system of eye sketched horizontal hachures. The water-level contours are of course a great improvement on the eye-hachures, and it was found that they could be executed almost as rapidly, even with little practice, and that the delay at first may be entirely put down to the change from one system to another. It is expected that the survey of the Dangs will be completed during the ensuing field season.

78. The survey of the city, cantonment, and environs of Surat includes an area of nearly 25 square miles, of which, however, 2·7 square miles within the city walls, having been previously carefully mapped and published on a large scale by the Guzerat Revenue Survey, was merely reduced to the 12-inch scale and incorporated with the new work.

* Major Holdich speaks of the work of Mr. McNair as being highly creditable to him. Sub-Surveyor Esuf Sharif's work is described as "very good," and that of Syad Ullah as "accurate."

INDEX CHART of the GUZERAT SURVEY.



TRIGONOMETRICAL BRANCH, SURVEY OF INDIA.

INDEX CHART OF THE CUTCH TOPOGRAPHICAL SURVEY.

Scale 1 inch = 16 miles

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dun, December 1908

Sheets 8, 9, 10, 11, 17 and 18 have been surveyed on the scale of 4 inch = 1 mile.

INDEX TO THE

No. 3 REV. PAINT.

N. W. PROVINCES SURVEY

REFERENCES.

Surveyed on scale 6" to 1 Mile 31-
" on scale 4"=1 mile during 1861-62
" on scale 4"=1 mile during 1862-63
Unsurveyed in advance.
Remaining for survey.
The numerals 1 2 &c. inclosed in this sketch on the scale of 1 inch = 1 mile 20' × 16', those printed in red are to be selected plots
Selected Forest Reserve

NOTE.

The figures and lines in dots represent limits and numbers of the suggested sheets of the Atlas of India.

The heights of G.T.S. stations refer to the top of the tower.

Scale 1 inch = 16 Miles

Photozincographed at the Surveyor General's Office, Calcutta.

Published under the direction of Lieut-General J.T. Walker, C.B. R.E. F.R.S. Surveyor General of India.

Surveyor General's Office, Calcutta, January 1865.

79. The operations of the past season bring the total area topographically surveyed in Guzerat up to about 15,686 square miles, leaving about 14,850 square miles to be done hereafter. Though the out-turn of work on the 2-inch scale is rather less than that of the previous year, the deficiency is more than counterbalanced by the largely increased area of work executed in the Dangs and the Surat large scale survey.

80. During the season an area of 1,705 square miles was prepared by triangulation and traversing for final survey, making, with the area prepared in previous seasons, an aggregate in advance of 3,400 square miles.

81. To meet the requirements of the Forest Department, the Bombay Government has expressed a wish that the survey of the Godhra, Kalol, and Halol talukas of the Panch Mahals should be prepared on the scale of 4 inches = 1 mile, the scale of the survey as hitherto executed in Guzerat being too small to suit the special requirements of forestry. This will be commenced during the ensuing season. A request has also been made by the Government of Bombay that certain villages in the Kolwan taluka, in the Nasik district, should be surveyed at an early date on the increased scale of 8 inches to 1 mile, with a view to the settlement and demarcation of the forests therein.*

X.—THE CUTCH TOPOGRAPHICAL SURVEY.

82. The operations of this party were conducted in a manner similar to that of last year, the mainland of Cutch being surveyed on the scale of 2 inches = 1 mile for publication on the 1-inch scale, while the sandy waste composing the Rann was mapped on the ½-inch scale. Of the former, an area of 1,619 square miles was completed, and of the latter 598 square miles, all lying immediately to the north of Bhuj, the capital of the province. This admits of the publication of sheets 17, 18, 19, 20, and 21 of the surveys, the two first on the ½-inch scale and the remainder on the 1-inch scale.

Personnel.

Lieutenant-Colonel A. Pullan, S.C., Deputy Superintendent, 3rd grade, in charge.
Mr. N. C. Gwynne, Surveyor, 4th grade.
" W. A. Fielding, Assistant Surveyor, 1st grade.
" George Hall " " 2nd "
" P. F. Prunty " " 3rd "
Sub-Surveyor V. R. Gadbole.
" N. D. Patwardhan.
" G. R. Bhopatkar,
and seven others.

83. Six hundred and twenty-two linear miles of traverse with chain and theodolite were carried over the work as a check on the plane-table survey, and also to furnish points for the ½-inch survey of the Rann. An area of 1,377 square miles was triangulated in advance on the western extremity of the Cutch Peninsula, which it is proposed to survey in detail next season.

84. The season under review was an unhealthy one, most of the Europeans and Natives being at one time or other laid up with fever.†

XI.—THE SURVEY OF DISTRICTS MEERUT AND BULANDSHAHR, NORTH-WEST PROVINCES (No. 3 PARTY, REVENUE BRANCH).

85. The field operations of this party were resumed on the 9th October 1881, whilst the party was under the superintendence of Major W. H. Wilkins. On Major Wilkins' transfer to No. 8 party in British Burma he made over charge, temporarily, on the 4th November, to Mr. James Todd, surveyor, who held it till 20th November, when he was relieved by Mr. E. T. S. Johnson. Field work was closed on the 15th April, when the party moved up to recess quarters at Mussoorie.

Personnel.

Mr. E. T. S. Johnson, Deputy Superintendent of Survey, 3rd grade, transferred from No. 6, or late Jaunpur Survey, on 21st November 1881.
Major W. H. Wilkins, Deputy Superintendent of Survey, 3rd grade, transferred to British Burma from 4th November 1881.
Mr. G. H. Cooke, Assistant Superintendent, officiating 1st grade, appointed to the party on return from furlough on 10th June 1882.
Mr. J. Todd, Surveyor, 3rd grade, in charge from 4th to 20th November 1881.
Mr. R. C. D. Ewing, Assistant Surveyor, 1st grade, transferred to the Deputy Surveyor-General's Office from 17th June 1882.
Mr. C. W. Wilson, Assistant Surveyor, 1st grade.
" C. W. F. Seyers " " 1st "
33 sub-surveyors, computers, &c.

86. The chief work of the party has been a topographical survey in districts Meerut and Bulandshahr on the 2-inch scale; but for the low-lying lands extending

* Colonel Haig reports:—"To Captain Hobday much credit is due for the energetic way in which he instructed the hands, both European and Native, in the use of the water-level and pushed on the work in the Dangs." He also reports very favourably of the work of each of the other members of the party.

† Lieutenant-Colonel Pullan reports that, thanks to the example of determination and pluck set by Mr. Hall, the Native surveyors strove well against the unhealthy climate, and worked on in spite of occasional attacks of fever.

along the Ganges and Jumna rivers in district Bulandshahr, the scale has been increased to 4 inches. With the 4-inch survey along the Jumna a small area of the Delhi district of the Punjab has also been surveyed, so as to include the entire area liable to be covered by the river in one series of maps; and, similarly, on the Ganges river, small portions of the Moradabad and Budaun districts have been surveyed and mapped with the opposite low-lying tract of Bulandshahr. On the maps of the 2-inch survey, village boundaries have been inserted by transfer from the settlement maps; with the 4-inch survey, village boundaries have been surveyed. The survey has extended down to the parallel of latitude 28°15′, and the area surveyed on the different scales and in the several districts is given in the following statement:—

Districts.	2-inch scale, in square miles.	4-inch scale, in square miles.	Total square miles.
Meerut	323·03	.....	323·03
Bulandshahr	1,173·02	138·00	1,311·02
Delhi	.....	5·51	5·51
Moradabad	.....	7·00	7·00
Budaun	.....	6·47	6·47
Total area ...	1,496·05	156·98	1,653·03

In addition to the above, 1,385·10 square miles have been traversed in districts Bulandshahr and Aligarh, in preparation for topographical survey in season 1882-83.

87. The same system of survey has been followed as in previous seasons, and the 2-inch survey has been made as minute as the scale will allow. Check lines aggregating 309 linear miles were measured as a test of this detail survey. The angular observations of the traverse survey were checked by 61 azimuths, observed at suitable intervals along the main circuits, and connections with stations of the Great Trigonometrical Survey enabled the chain measurements of the circuits to be adjusted to accord with trigonometrical distances.

88. The transfer of the village boundaries from the settlement maps to the 2-inch sheets was provided for by adopting the trijunctions of the boundaries, which had been permanently marked at the time of the settlement survey, as traverse stations. These trijunctions, which originally were low masonry platforms, are the only permanent marks which have been left at traverse stations; and these are not very satisfactory, as many of the platforms were found in a dilapidated condition. Under instructions of the Government Resolution No. 45S, dated 4th September 1882, paragraph 5, the permanent marking of all the stations, of which there are many more besides the stations at the trijunctions, will in future be attended to.

89. During next season, the detail survey of district Bulandshahr will be completed, and that of district Aligarh will be continued. The preparatory traverse survey will be extended into district Etah.

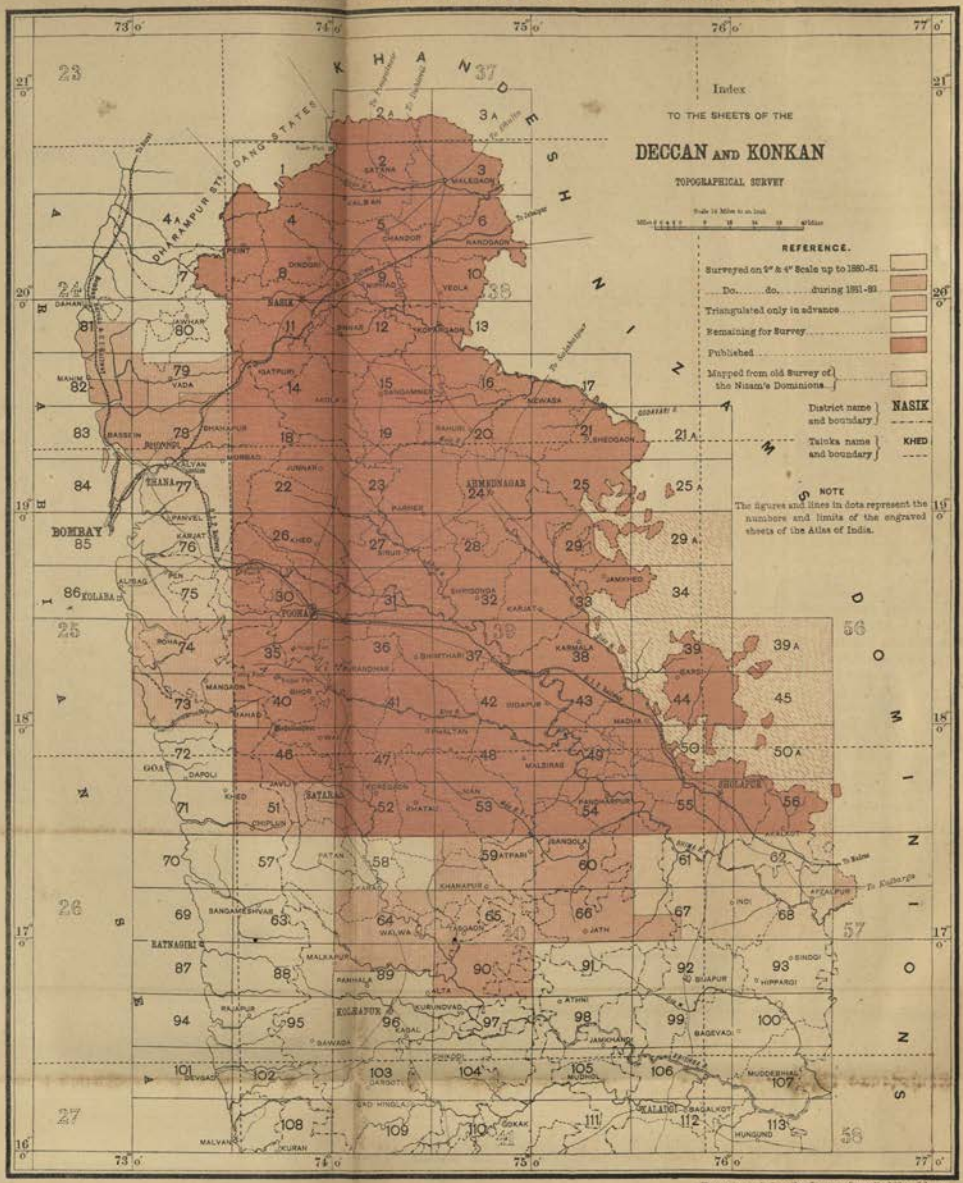
90. The fair maps of the completed area have been drawn and submitted ready for publication by photozincography. They consist of—

19 sheets on 2-inch scale for publication on same scale.
19 sheets on 2-inch scale for reduction to 1-inch scale.

The sheets of the Ganges and Jumna rivers survey, 27 in number, have also been drawn, but these will not be published. Tracings of them have been furnished for record in district offices.*

* Mr. Johnson reports very favourably on the services of Mr. G. H. Cooke, Mr. Todd, Mr. Ewing, Mr. Wilson, and Mr. Seyers, and names the following members of the native establishment as having done well and given satisfaction, viz. Kedar Nath, Bhugobutty Churn Chuckerbutty, Didar Bux, Sarfraz Khan, Nejabut Hosain, Mahomed Zakaria, Alladad Khan, Bashirudin, Boithram, and Abdul Karim.

DECCAN AND KONKAN TOPOGRAPHICAL SURVEY.



Photozincographed at the Surveyor Generals Office, Calcutta

Published under the direction of Lieut-General J.T.Walker, C.B-R.E-F.R.S., Surveyor General of India.

Surveyor Generals Office, Calcutta, January 1863.

XII.—THE SURVEY OF THE SOUTHERN COLLECTORATES OF THE DECCAN BOMBAY PRESIDENCY (No. 11 PARTY, REVENUE BRANCH).

91. The field operations of this party were resumed, under the control of Major D. C. Andrew, on 10th November1881, and closed on 10th May 1882. The survey has been entirely topographical, on the scale of 2 inches to a mile, and is mainly comprised in standard sheets 60, 66, and 90 of the Deccan series. A few small portions in other sheets have also been surveyed, and the survey has operated in several collectorates and native states, as is shown in the following statement:—

Personnel.

Major D. C. Andrew, Deputy Superintendent, 3rd grade.
Mr. S. M. Smylie, Surveyor, 3rd grade.
„ J. Hickie, Assistant Surveyor, 1st „
„ G. C. Swiney „ „ 1st „
„ W. H. Penrose „ „ 2nd „
„ transferred to No. 8 Party, Bassein District Survey, from 1st November 1881.
Mr. G. A. Knight, Assistant Surveyor, 2nd grade.
18 sub-surveyors and others.

	Square miles.
Sholapur collectorate	472
Satara ditto and 3 dependent states	742
Kaladgi ditto	51
Belgaum ditto and 1 dependent state	70
Kolaba ditto	72
Kolhapur state and 7 other dependent states under the Southern Mahratta Agency	537
Nizam's dominions	130
Total ...	2,074

The portion of the Nizam's dominions has been surveyed, as there are no maps of this tract forthcoming with the records of the Hyderabad survey.

92. Besides the above area of topographical survey, 2,016 square miles have been triangulated and traversed in advance for topographical work next season.

The topographical survey has represented the features as minutely as the scale would admit of, and grass-lands have been carefully separated from cultivation. This work has been tested by 368 linear miles of measured check surveys. The heights of 113 stations have been determined trigonometrically. The country is reported to be undulating and possessing no features worthy of note, except a range of hills separating the Sholapur from the Satara district. The villages are few and far apart, and the scanty supply of good drinking-water was severely felt by the party when the hot months set in.

The triangulation stations have been well marked with stones about 2 feet long sunk in the ground, over which, after completion of the observations, mounds of stones and earth were raised. The traverse stations have, as a rule, been placed on demarcated trijunctions of fields, a special mark being cut on the demarcation stones which have been adopted as stations.

93. The fair drawing of the standard-sized sections has all been completed during the recess, 33 two-inch sections having been drawn and sent to Calcutta ready for publication on the 1-inch scale by photozincography.

The survey of the city of Sholapur on the scale of 80 inches to a mile, at the expense of the municipality of that town, has been completed, and the sheets, 59 in number, finally drawn and rendered in a style fit for printing by photozincography. The printing will be done in the Government Photographic Press at Poona, according to the arrangements that may be made by the Sholapur Municipality for defraying the printing charges. A survey of the town of Pandharpur, in the Sholapur district, on the 80-inch scale, at the expense of the municipality, has been commenced.

94. The recess office of the party was inspected at Poona during August by the Deputy Surveyor-General, who was satisfied that much care had been taken to render the survey searching and accurate.*

* Major Andrew reports that his assistants, Messrs. Smylie, Hickie, Swiney, and Knight, have afforded him entire satisfaction.

XIII.—HOOGHLY RIVER SURVEY (No. 6 PARTY, REVENUE BRANCH).

95. The order for undertaking this survey was communicated in letter No. 98, dated Simla, the 3rd September 1881, from the Secretary to the Government of India, Revenue and Agricultural Department, to the Surveyor-General.

Personnel.

E. T. S. Johnson, Esq., Deputy Superintendent, 3rd grade, in charge up to 15th November 1881.
Major S. H. Cowan, Officiating Deputy Superintendent, 4th grade, in charge from 7th April 1882.
Lieutenant-Colonel E. P. Leach, V.C., R.E., Assistant Superintendent, 1st grade, in charge from 16th November 1881 to 6th April 1882.
Mr. J. S. Pemberton, Surveyor, 3rd grade.
„ J. S. Swiney, Assistant Surveyor, 1st grade, transferred to No. 7 party on 14th April 1882.
Mr. C. S. Kraal, Assistant Surveyor, 3rd grade.
„ P. C. H. Smart „ „ 3rd „
31 sub-surveyors and others.

96. The want of a reliable survey of the Hooghly river, brought up to date, had been felt for some time, and had been noticed by the Torpedo Committee in 1871, by the Bengal Chamber of Commerce in 1872, by the Port Commissioners in 1875, and finally by the Port Officer of Calcutta, who addressed the Bengal Government in March 1881, stating that an exact triangulation and topographical survey of the banks of the river were much needed to be used as a basis for new river charts, and asking that the co-operation of the Survey Department might be obtained.

97. The Surveyor-General had long been aware of the defective state of the maps of the Hooghly river, the best of which had been compiled in 1875 to meet the requirements of the Torpedo Committee; but this map is on a scale (4 inches = 1 mile) quite inadequate to the proper delineation of the country bordering the river in the vicinity of Calcutta: and the only materials available for the greater part of the compilation had been the surveys of the 24-Pergunnahs in 1847–49 and district Hooghly in 1869–73. He accordingly took advantage of the opportunity offered by the completion of the cadastral survey of Jaunpur district, which left No. 6 party of the Revenue Branch at his disposal, and recommended to the Government of India (letter No. 166F, dated 17th June 1881) that the resurvey of the Hooghly river should be commenced in the ensuing field season.

98. The party assembled at Barrackpore on the 10th November 1881, under charge of Mr. E. T. S. Johnson, who was relieved on the 16th by Colonel Leach. Colonel Leach remained in charge until the 7th of April 1882, when he went on furlough and was succeeded by Major S. H. Cowan.

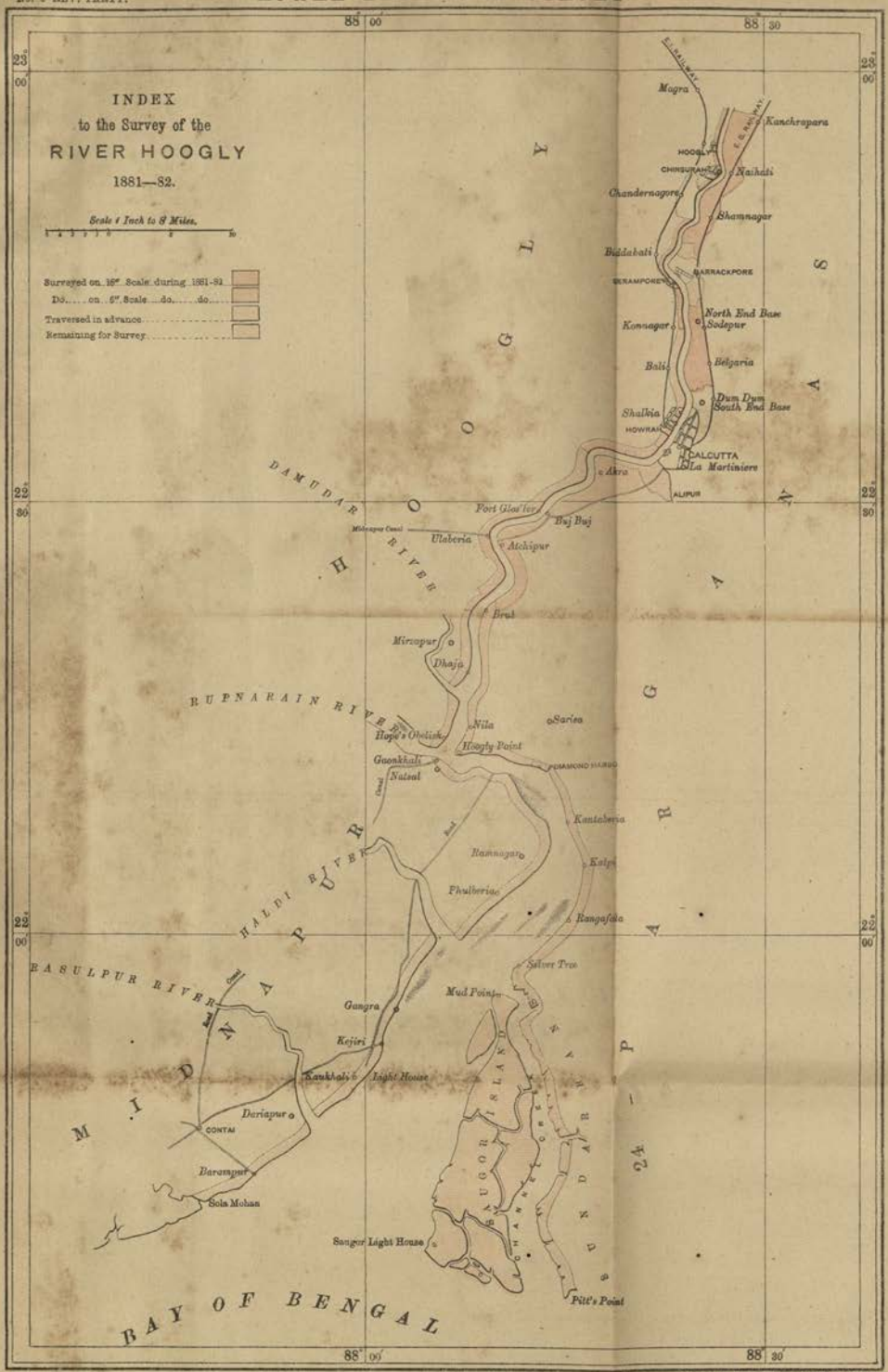
99. On the left bank of the Hooghly river the tract to be surveyed extends from the northern limit of the 24-Pergunnahs near Kanchrapara station of the Eastern Bengal Railway, by Barrackpore, Baranagar, Calcutta, Akra, Atchipur, Diamond Harbour, and Channel Creek to Pitt's Point on the sea-face of the Sundarbans; on the right bank, from a point opposite Kanchrapara through Hooghly, Chinsurah, Chandernagore Serampore, Bali, Howrah, Fort Glo'ster, Ulubaria, Gewankhali, &c., to the Sola Mohan Creek in district Midnapore. The width of the strip surveyed on each bank varies from a quarter mile to one mile and upwards. The suburbs of Calcutta known as Alipur, Kidderpur, and Garden Reach are to be surveyed, and also the whole of Saugor Island. Barrackpore, Calcutta, and the Government estate of Punchannogram on the left bank, and Chandernagore on the right bank, are excluded.

100. The Port Officer at first asked that the survey from Calcutta to Diamond Harbour might be made on the scale of $\frac{1}{12,000}$ (5·28 inches to a mile), and from Diamond Harbour to the sea on the scale of $\frac{1}{24,000}$ (2·64 inches to a mile); but the Vice-Chairman of the Port Commissioners recommended in November 1881 that a uniform scale of six inches to a mile, or $\frac{1}{10,560}$, should be adopted: and this scale has been used from Atchipur downwards. Above Atchipur the scale is 16 inches to a mile.

101. The field season commenced on the 10th November, but the early operations were completely paralyzed by a severe outbreak of cholera among the khalassies on the 17th, 18th, and 19th of November, which resulted in 14 seizures and 14 deaths, and necessitated the insulation of the men. There had been unfortunately no opportunity of preparing traverses in advance, so that there was considerable delay before the detail survey could be fairly commenced. The establishment was withdrawn from the field between the 15th and 25th of June.

No. 6 REV. PARTY.

LOWER PROVINCES SURVEY



Photozincographed at the Surveyor General's Office, Calcutta

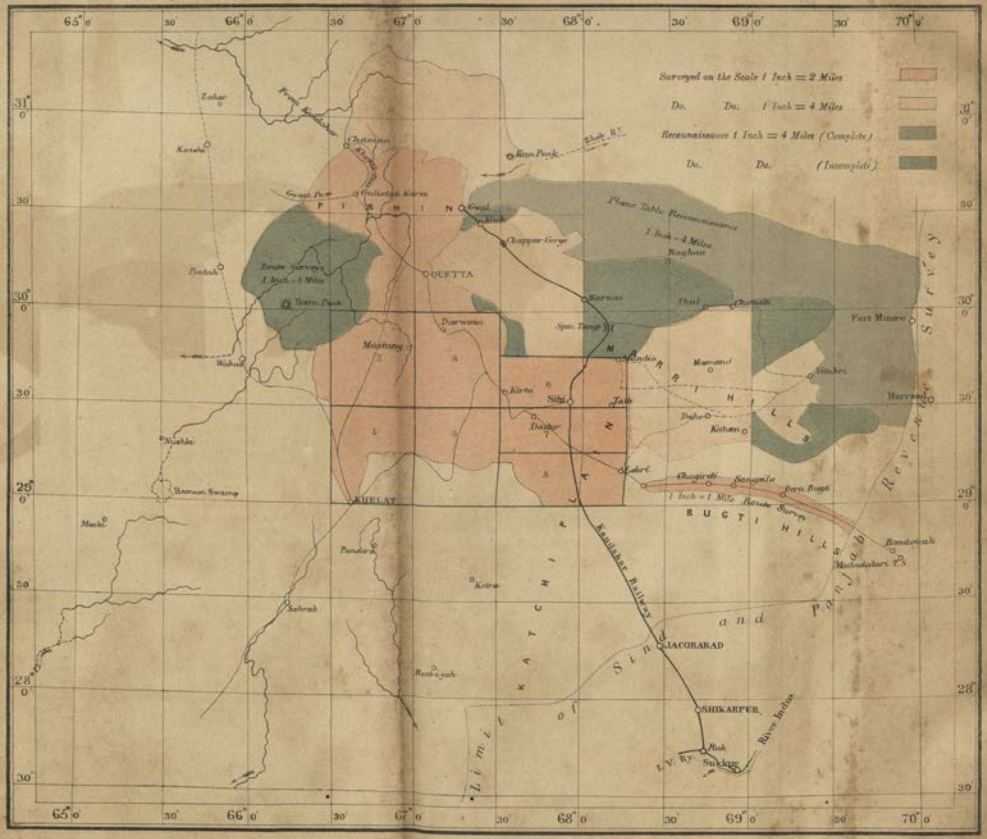
Published under the direction of Lieut General J.T. Walker, C.B., R.E., F.R.S., Surveyor General of India.

Surveyor General's Office, Calcutta, January 1883.

INDEX to the SHEETS of the BALUCHISTAN SURVEY.

On the Scale of 1 Inch = 2 Miles, and 1 Inch = 4 Miles.

To accompany Surveyor General's Report for 1881-82.



Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India.

at the Surveyor General's Office, Calcutta, December 1882.

102. During the past field season the left bank survey was completed down to the Punchannogram boundary near Cossipore, excepting the tract immediately round Barrackpore and some small areas near Baranagar. All the country between the river and the Eastern Bengal Railway was surveyed; and in places where the railway approaches the river, the survey was carried beyond it, so as to give the tract a uniform width of about one mile. The right bank has been completed from the northern limit opposite Kanchrapara down to Konnagar, but on this bank the strip surveyed is only a quarter mile wide. Large scale maps of this tract, sufficient for most purposes, have already been published (1873); and to have worked up to one mile from the river would have increased the work enormously, as a large proportion of the area is closely built over. The above work has been surveyed and plotted on the scale of 16 inches = 1 mile. A commencement has also been made of the 6-inch work, and both banks of the river from Atchipur to near Brul Semaphore Tower, or for about 6 miles, have been surveyed on this scale. The total area surveyed on the 16-inch scale was 21,063 acres (32·91 square miles), and on the 6-inch scale 9,137 acres (14·28 square miles). The areas remaining for survey in 1882-83 are estimated at:—16-inch work, 20,874 acres = 32·6 square miles; 6-inch work, 1,12,960 acres = 176·5 square miles.

103. The area surveyed on 16-inch scale has been closely tested by lines of check surveys and by resurveys of small blocks. The measured traverses have been connected with the numerous stations and points of the Great Trigonometrical Survey falling within the area surveyed, and the chain measurements have been corrected to accord with the trigonometrical distances. The bearings of the traverse lines were checked by 16 stellar observations and 4 azimuths of the Great Trigonometrical Survey.

104. The 6-inch work of this party has already been utilised by the River Survey Department, and a chart, showing the Atchipur Bar and the reach of the River Hooghly from Atchipur to Raipur, was printed in July 1882, in which the shore details were copied from the original field sheets of No. 6 party and the soundings were taken during the month by the River Survey Department. During next field season the survey of the shore details from Calcutta to the sea will be completed on the same scale, and will similarly be made available to the public as fast as the soundings of the various reaches of the river most urgently requiring revision are completed. This work is being energetically pushed on by Lieutenant Petley, R.N., and the result of the joint surveys and of the leveling, now in progress, will soon be to furnish an admirable survey of the River Hooghly.

105. Iron sockets have been planted by the River Survey Department along the banks at an average distance apart of about one mile: between each of these another permanent mark will be fixed by No. 6 party; the positions of all these marks will be carefully determined and plotted, and they will afford the means of accurately recording all future changes in the channel of the river, besides being always useful as points for the River Survey to work upon in running their lines of soundings, which, owing to the incessant fluctuations of the sands and shoals in the river, require continual attention and revision.*

XIV.—THE BELUCHISTAN SURVEY.

106. The work in hand by this party, at the time of publication of last report, was continued throughout the winter by it under Major Beavan, in the country lying between Quetta and Kelat; the season's work comprising more especially that part adjacent to the Bolan and Rodbar passes. The topography was executed on the ½-inch scale, but with varying degrees of detail and accuracy, according as the country was more or less safe for the surveyors to work

Personnel.

Major R. Beavan, S.C., Officiating Deputy Superintendent, 4th grade, in charge.
Mr. J. T. U. Coxen, Assistant Surveyor, 1st grade.
„ H. Corkery „ „ 2nd „
Sub-Surveyor Abdul Rasul.
Ditto Barkat Ali,
and one other.

* Major Cowan speaks highly of his European assistants, Messrs. Pemberton, Kraal, and Smart; and while commending all the members of the Native establishment, makes particular mention of sub-surveyor Dilwar Khan.

in. Thus the triangulation could not always be pushed forward in advance of the topography as is desirable, but in several instances the two operations had to be carried on simultaneously, the triangulation correcting instead of furnishing a basis for the topography. About 4,300 square miles of country were thus mapped.

107. Major Beavan himself received orders to accompany a military expedition under Brigadier-General H. C. Wilkinson to open out the routes between Thal Chotiali and Dera Ghazi Khan. In addition to making a plane-table reconnaissance of such portions of the route taken—*viâ* Mandai, Thal, and Chamalang—as were hitherto unsurveyed, Major Beavan took advantage of such opportunities as occurred for getting observations to complete the Sewestan triangulation. Subsequently Major Beavan, accompanied by Mr. Corkery and under the protection of an escort of Marris, furnished by the Assistant Agent, pushed forward into the Marri country in order to continue, as far as possible, the survey of that district.

108. The party left the field for recess quarters on the 25th March, having been in the field uninterruptedly for 12 months.

109. This survey will be continued during the coming season, the Native surveyors resuming work near Kelat to continue their previous work, and the European assistants being employed in extending the triangulation over the Khetran country and the Bugti hills.*

MAUZAWAR OR VILLAGE SURVEY.

XV.—DERA ISMAIL KHAN, MUZAFFARGARH, AND RAWALPINDI DISTRICTS (No. 1 PARTY, REVENUE BRANCH).

110. This party, under charge of Lieutenant-Colonel D. Macdonald, on leaving its recess quarters at Murree, took the field in two sections. One section proceeded to the Derajat to continue the survey of pargana Leiah of district Dera Ismail Khan, and to undertake the survey of the *Thal* portion of district Muzaffargarh; the second section proceeded to the "Kala Chitta Pahar" to continue the survey of that portion of the Rawalpindi district. Both sections completed the areas assigned for survey in each of the tracts, and the work accomplished is shown in the following statement:—

Personnel.

Lieutenant-Colonel D. Macdonald, Deputy Superintendent, 2nd grade, in charge.
Mr. G. B. Scott, Surveyor, 3rd grade, detached under settlement officer of Rawalpindi from 13th December 1881.
Mr. W. S. Buttress, Surveyor, 3rd grade.
" A. J. Gibson " 3rd "
" R. Todd, Offg. " 4th "
" G. Campbell, Assistant Surveyor, 2nd grade, returned from furlough and joined this party on the afternoon of 21st September 1882.
Mr. J. C. Kelly, Assistant Surveyor, 3rd grade.
22 sub-surveyors and others.

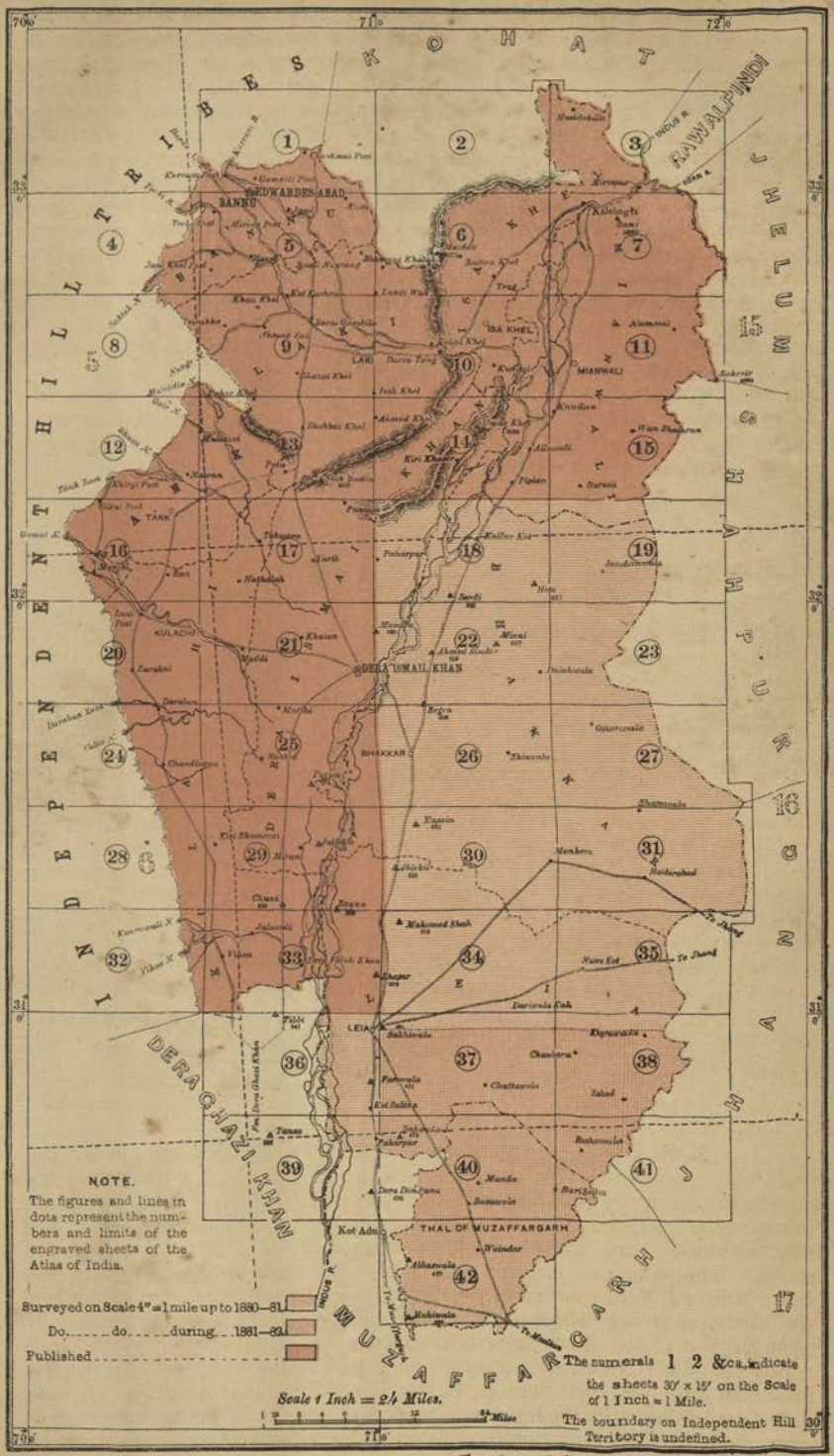
District.	Pargana and locality.	Number of villages.	Area in square miles.	Scale of survey.
Dera Ismail Khan	Leiah	23	889·44	4 inches=1 mile.
Muzaffargarh	Pargana Sinanwan (Thal portion) ...	43	785·22	Ditto.
Rawalpindi	Kala Chitta Pahar...	.....	190·20	Ditto (for the use of the Forest Department).
Total ...		.....	1,864·86	

111. In the Derajat, pargana Leiah of Dera Ismail Khan had been prepared for survey by skeleton traversing during the previous season, and the topographical survey was therefore first undertaken there. Meanwhile, the traversing of pargana Sinanwan of Muzaffargarh was taken in hand, and both traversing and topography were completed in that pargana in one season. The portion of pargana Sinanwan which has been surveyed is the entire tract of *Thal* country included in district Muzaffargarh, and which had been surveyed on the 1-inch scale without village boundaries being delineated, when the rest of the Muzaffargarh district was surveyed on the 4-inch scale during 1855-56. The 4-inch survey of the district is now complete. In pargana Sinanwan four principal stations of the Great Trigonometrical Survey have been incorporated with the measured traverses, the latter being corrected to correspond with the trigonometrical distances by introducing corrections which

* Major Beavan reports favourably of all his assistants.

PUNJAB SURVEY

No. 1 REV. PARTY. INDEX MAP OF DISTRICTS DERA ISMAIL KHAN & BANNU.



Photozincographed at the Surveyor General's Office, Calcutta

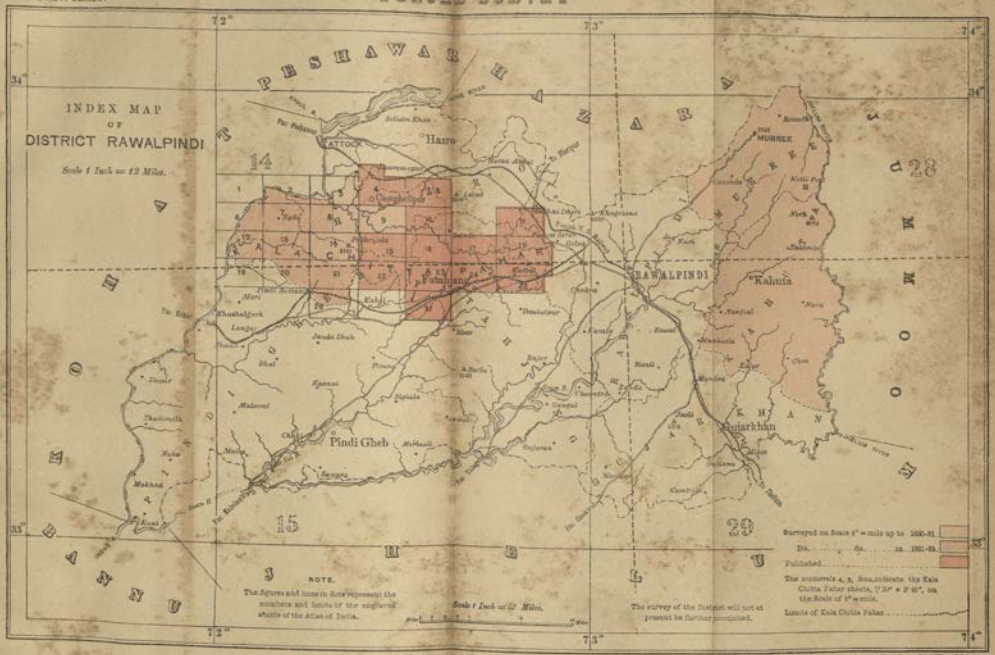
Published under the direction of Lieut General J.T.Walker, C.B.-R.E.-F.R.S., *Surveyor General of India.*

Surveyor General's Office, Calcutta, January

1883.

No. 1 REV. PARTY.

PUNJAB SURVEY



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Surveyor General's Office, Calcutta, January 1865.

averaged 5·2 feet per mile. Observations for azimuth were taken at 23 traverse stations, and 242 linear miles of check surveys were measured.

112. In the Kala Chitta Pahar, owing to the rugged nature of the country, the topography was based on points fixed by triangulation, not on measured traverses. Colonel Macdonald, who has drawn up a few "notes" on the entire range, which are printed in the appendix at page 30, thus briefly describes the country under survey last season:—

"The hills were very broken, rough, and precipitous. There was a great scarcity of water. Provisions were difficult to procure, and had to be brought long distances."

The rate of progress of the topographical survey in such country was necessarily slow. One-third of a square mile was the daily average outturn of each topographer, which is less than a quarter of the daily average of the men who were employed in the Derajat. The accuracy of the survey in all the sheets was tested, either by check surveys or by examination *in situ*.

113. The season's out-turn of fair maps is as follows:—

Of pargana Leiah 37 four-inch sheets (projected on rectangular co-ordinates) have been drawn, which complete the series for the Dera Ismail Khan district.

Of pargana Sinanwan, district Muzaffargarh, a special separate series of 69 sheets, each sheet comprising $3\frac{3}{4}'$ latitude × $3\frac{3}{4}'$ longitude, has been drawn.

Of the Kala Chitta Pahar, 14 sheets have been drawn, completing a series of 27 sheets of the standard size of $3\frac{3}{4}'$ latitude × $7\frac{1}{2}'$ longitude for the entire tract.

The drawing of the 4-inch sheets of Murree and Kahuta tahsils, surveyed by this party from 1877 to 1880, is still incomplete, awaiting the adjustment of the forest boundaries.

114. Mr. G. B. Scott, one of the surveyors of this party, was deputed, at the request of the Government of the Punjab, during September, October, and November 1881, to the Sialkot district to survey two portions of the Chenab river, where there were disputes of long standing regarding the boundary between British territory and the territory of his Highness the Maharajah of Kashmir. Some village lands adjoining the disputed boundaries were also required to be surveyed, and Mr. Scott surveyed in all an area of 11·3 square miles. Mr. Scott's maps, showing also the lines of old boundaries by transfer from previous survey maps, which he prepared under the superintendence of Colonel Macdonald, have been photozincographed, and copies of them were furnished to the Government of the Punjab during January 1882.*

XVI.—THE SURVEY OF THE THANA DISTRICT (KONKAN), BOMBAY PRESIDENCY (No. 10 PARTY, REVENUE BRANCH).

115. The field operations of this party were resumed under the direction of Major H. Lees Smith on the 25th of November 1881. During the field season Major Lees Smith suffered much from malarious fever; he ought to have proceeded on leave for the benefit of his health, but he remained devotedly at his post and succumbed to the disease at Poona on 23rd April. Major Lees Smith was possessed of considerable mathematical talent, and his loss to the department is much regretted. Mr. A. M. Lawson received charge of the party on the death of Major Lees Smith, and under his

Personnel.

Major H. Lees Smith, Officiating Deputy Superintendent, 3rd grade, in charge to date of death, 23rd April 1882.
Major J. Hill, R.E., Deputy Superintendent, officiating 3rd grade, in charge from afternoon of 23rd June.
Captain G. W. Martin, Officiating Assistant Superintendent, 2nd grade, joined this party on the 24th June 1882, and was transferred to Bombay Mint on September 1882.
Mr. A. M. Lawson, Surveyor, 3rd grade, in charge from 24th April 1882 to 23rd June.
Mr. J. Newinnd, Assistant Surveyor, 1st grade.
„ W. M. Kelly „ „ 2nd „
„ R. R. Dickinson „ „ 2nd „
20 sub-surveyors and others.

* Colonel Macdonald reports as follows on his assistants:—
"Mr. W. S. Buttress is a very steady, able, and painstaking assistant."
"Mr. Gibson was an excellent hill surveyor and a good draftsman; he did good service both in field and office."
"Mr. Todd, as usual, worked very hard. He is a very good plane-tabler, and never spares himself."
"Mr. Kelly is a steady assistant."
The following men of the native establishment are specially brought to notice, viz. sub-surveyors Eed Mahomed, Ramtonoo Chuckerbutty, and Goordit Singh, and English writer Elahi Bux.

charge field operations were brought to a close on 31st May. Major J. Hill relieved Mr. Lawson of the charge at Poona on 23rd June.

116. The scale of survey was 4 inches to the mile in place of the ordinary Deccan and Konkan scale of 2 inches to the mile. The change has been made under authority of Government of India, Home Department, letter No. $\frac{F}{330}$, dated 20th September 1881, in accordance with the resolution of the Government of Bombay, representing that maps on the 2-inch scale are insufficient for the administration of forests, which cover large areas of the Thana district. It had been expected that the forests only need have been surveyed on the increased scale; but after due inquiry it was found to be advisable, on account of the forests being so much scattered over all parts of the district, to survey the whole tract on one scale. Another reason for surveying the whole tract on the 4-inch scale was, that the boundaries of the forests had not been finally determined.

The forest officers, when recommending the adoption of the 4-inch scale for forests in the portion of the Thana district remaining for survey, have also urged the necessity for remapping the forests that had already been surveyed on the 2-inch scale. Their recommendation, for the present, has not been allowed, but maps on the 2-inch scale have been printed specially for forest purposes, in addition to the usual publication of the topographical maps on the 1-inch scale.

117. The agreement with the Government of Bombay concerning the increase of scale is that the Forest Department of that presidency is to be charged with the additional cost of the more expensive survey. The area surveyed by the party was 940 square miles, costing Rs. 50,181; of which, as extra cost of 4-inch survey, Rs. 18,624 have been debited to the Government of Bombay.

In addition to the area which has been mapped, 450 square miles have been triangulated and traversed for detail survey next season.

118. The traverse stations of the survey are fixed on field demarcation stones with a special mark cut upon them. The heights of 208 points have been determined trigonometrically, fixing many valuable points, such as hill-passes, junctions of streams, wells, and mile-stones. The topography has been executed by a close survey of all the details, and at the request of the Forest Department particular attention has been paid to recording the names of all peaks, valleys, passes, springs, shrines, &c. The conformation of the hilly ground has been indicated by the system of horizontal shading, a vertical interval of 25 feet being preserved between the *hachures*. Towards the coast, the country surveyed is much cut up with tidal creeks and salt marshes; inland, towards the ghâts, there is a very large area of hilly ground covered with forest; and in the centre of the tract, a small extent of open and cultivated country. The party suffered severely from the unhealthiness of the country from the time of taking the field up to January, and a large number of men were permanently incapacitated.

119. The drawing of 24 four-inch sections of the standard size, comprised within sheets Nos. 78, 79, 82, and 83 of the Deccan and Konkan series, has been completed, and the sheets will be published on the original scale. Reductions of the sections are being drawn for publication, similarly to the other sheets of the series, on the 1-inch scale.

120. The recess office of the party was inspected at Poona during August by the Deputy Surveyor-General, who expresses himself well satisfied with the style of the work which had been executed.*

---

* Major Hill reports as follows on the assistants of his party:—

He speaks highly of the services of Captain G. W. Martin during the short time he was attached to the party.

"On Mr. Lawson," he says, "an unusual responsibility was imposed during the latter part of the field season and early part of the recess owing to the illness and death of Major Lees Smith, which he well sustained as officer in charge of the party."

Mr. Newland is spoken of as "a cheerful, zealous and hard-working assistant, of high character and devoted to his work."

Mr. Kelly is said to have worked well and steadily, but he had not paid sufficient attention to details in his topography.

Mr. Dickinson is said to be a very good hill-surveyor and draftsman, of whom Major Hill further says he has every reason to be satisfied.

Sub-surveyors Fyzulah Khan and Nathu Lall are named as being deserving of special commendation.

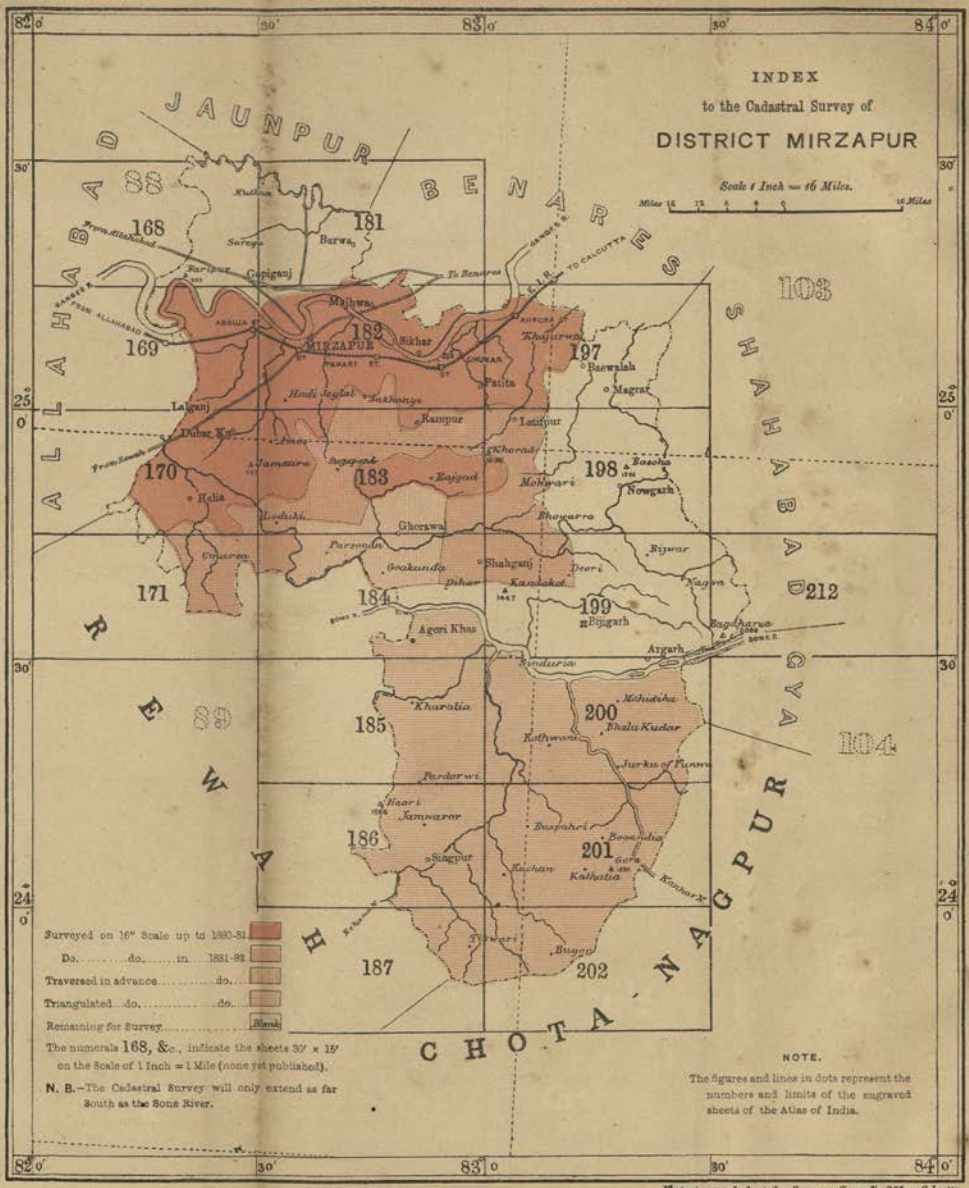
No. 5 REV. PARTY.

N. W. PROVINCES SURVEY

Published under the direction of Lieut. General J. T. Walker, C.B., R.E., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, January 1901.

No. 5 REV. PARTY.

N. W. PROVINCES SURVEY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MIRZAPUR
Surveyed on 16" Scale up to 1880-81
Do. do. in 1881-82
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Triangulated do. do.
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N. B.—The Cadastral Survey will only extend as far South as the Sone River.
NOTE.
The figures and lines in dots represent the numbers and limits of the engraved sheets of the Atlas of India.

Photozincographed at the Surveyor Generals Office, Calcutta.

Published under the direction of Lieut-General J. T. Walker, C.B., R.E., F.R.S., *Surveyor General of India.*

Surveyor Generals Office, Calcutta, January
1883.

CADASTRAL OR FIELD SURVEY.

XVII—MIRZAPUR DISTRICT, NORTH-WEST PROVINCES (No. 5 PARTY, REVENUE BRANCH).

Personnel.

Colonel F. C. Anderson, Deputy Superintendent, 1st grade, in charge.
Mr. C. W. Campbell, Surveyor, 1st grade.
" E. S. P. Atkinson " 3rd " transferred from No. 7 Topographical Survey Party from 1st October 1881, and transferred to Mysore Topographical Survey from 30th April 1882.
Mr. E. G. Little, Surveyor, 4th grade.
" R. B. Smart, Assistant " 1st " transferred to No. 8 Revenue Party from 1st November 1881.
Mr. T. F. Freeman, Assistant Surveyor, 1st grade, on sick leave from 1st May 1880.
Mr. T. Shaw, Assistant Surveyor, 1st grade.
" W. D. Corbett, " " 1st " transferred from No. 4 Revenue Party from 1st October 1881.
Mr. E. P. S. Hill, Assistant Surveyor, 2nd grade.
" G. D. Smart, " " 3rd " appointed from 1st October 1881.
20 sub-surveyors and others.

Temporary Establishment.

253 field surveyors and others.

121. This party, under charge of Colonel F. C. Anderson, returned from recess quarters at Nainital and resumed field work in the Mirzapur district on 1st November. The season's operations in this district have included portions of parganas Bhagwat and Ahraura, situated in the Gangetic valley, and portions of parganas Kantit and Barhar, forming part of the up-lands. A small detachment of the party has been employed during the season in continuing the cadastral survey of a few villages in parganas Bazpur and Gadarpur, of district Tarai. The survey in both districts has been done on the 16-inch scale, and the areas accomplished are shown in the following statement:—

District.	Number of villages.	Square miles.
Mirzapur	645	734
Tarai	19	16
Total	664	750

122. In the Mirzapur district, north of the Sone river, the preliminary boundary traversing of 329 square miles has been done in preparation for cadastral survey in 1882-83; and in the same district, south of the Sone, 1,790 square miles, comprising parganas Singrauli, Agori, and Dudhi, where a cadastral survey is not required, have been triangulated in preparation for a topographical survey.

123. Besides purely survey work, to which the operations of the Survey Department in carrying out cadastral surveys in the North-Western Provinces have hitherto been restricted, this party has been engaged during the past season in preparing, simultaneously with the maps, the village *khasras*, which in former years and in other districts have been drawn up by a separate establishment, working under the orders of a settlement officer, after the maps have been completed. This new duty of writing the khasras has been undertaken at the request of the Board of Revenue, in accordance with a scheme submitted by Colonel Anderson, who had been consulted by the Board and asked to suggest a remedy for the high aggregate cost of the entire operations going on in the permanently settled districts of survey and subsequent preparation of papers connected with the Record of Rights. Colonel Anderson considered that no appreciable reduction would be possible on the present cost of the survey, except, it might be, by an increase to the annual grant, so as to provide for a larger subordinate staff and an increased outturn; but he was confident that a large saving could be effected in the expenditure for the Record of Rights by utilising the survey staff:—

1st.—To fill in all the columns of the khasra by making the necessary inquiries during the progress of the measurements.

2nd.—To supervise the *putwaris* in the preparation by the latter of a copy of the khasra *pari passu* with the survey.

3rd.—To compile from the khasras the "*jummabundi* slips," *i.e.* the separate statements of fields held by each cultivator, leaving the rent columns to be filled in by the putwaris.

4th.—To prepare fair copies of the khasras after the work of the settlement staff as regards disputes had been completed and attestations of proprietors and cultivators obtained.

Colonel Anderson estimated that the extra duties, as sketched above, would add Rs. 10 per square mile to the cost of the survey.

124. By Colonel Anderson's scheme, the *khewats* (statements showing the shares of rent paid by the proprietary body) would be prepared by the putwaris, and the adjustment of disputes as to names entered in columns 3, 4, and 5 of the khasra would be the first duty of the settlement staff, the existence of disputes being brought to notice by the surveyors in a list attached to the khasra. The settlement staff would then obtain the attestations of the proprietors and cultivators to the rent rolls; and finally, the fair copies of the khasras would be written in the Survey Office.

The Board of Revenue approved of the scheme as an experimental measure, and requested it might be carried on provisionally, leaving the question of its adoption for other districts to be considered when the experiment would be completed by the work of the settlement staff during the following season.

In practice, one very great advantage to the survey work itself resulted from the new duty of writing the khasra, in so much that the surveyors were able to secure the regular attendance of zemindars and cultivators to point out the boundaries of the fields, and thus their labour was much reduced by being saved from having to survey interior subdivisions of fields for want of information regarding the true field boundaries. When khasras are being written, the putwaris, to whom all the field boundaries are as a rule well known, must also be present. Specimens of the *khasras* and *jammabandi* slips, specially designed by Colonel Anderson in consultation with the Collector of Mirzapur, are given at page 93 of the appendix.

125. The area surveyed included a large aggregate extent of hilly and uncultivated country which, it had been expected, might have been surveyed on the 2-inch scale; but the cultivated tracts were found to permeate through all parts of the hills, and it was deemed more advantageous to include the whole country in the large scale survey than to separate small detached tracts for a two-inch survey. Out of the entire area of 734 square miles, the waste tracts and plots of waste mixed up with the cultivation are said to cover 371 square miles. In the cultivated tracts, 346,140 fields have been surveyed, giving ·67 of an acre as the average size for each field if calculated on the cultivated area only, and 1·36 acres if calculated on the total area.

126. The field survey has been carefully tested by check lines measured by the European assistants and Native inspectors, 207 linear miles of checks having been done by the former and 1,256 by the latter officers. The chain traverses have been connected with six Great Trigonometrical Survey stations, and a comparison of the results of the corrections shows that there was an average error in the chaining of 1·9 feet per mile. Azimuth observations were taken at 11 traverse stations. In the triangulation south of the Sone, which has been based on the rays connecting four principal stations of the Great Trigonometrical Survey, 29 secondary stations have been fixed, from which the positions of 330 intersected points have been determined.

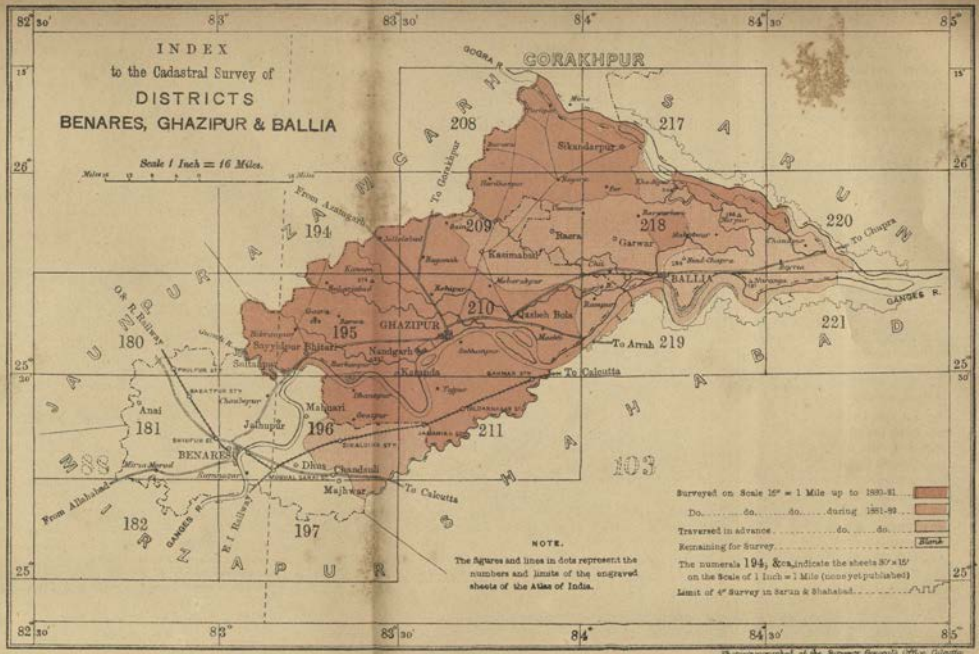
The trijunctions of village boundaries had been, as usual, permanently marked by the district staff previous to survey. In addition to these marks, the theodolite stations of the boundary traverses have been marked by the surveyors with specially cut stones, the cost of which, as they are regarded as part of the boundary demarcation, is to a certain extent borne by the land-owners. The surveyors have again been engaged in relaying many lines of boundary, according to the maps of Captain Wroughton's survey of 1839–41, where disputed lines could not otherwise be settled.

127. The cadastral survey in Mirzapur has been mapped on 955 sheets, and in Tarai on 22 sheets. Of these, all the Tarai sheets and 573 Mirzapur sheets have been lodged in the Calcutta office; more than half the remainder are kept back on account of disputed boundaries. There are also 64 sheets of previous seasons awaiting final disposal pending the adjustment of boundaries. The general maps of Mirzapur are being drawn on the 2-inch scale for publication on the 1-inch; none have yet been completed, as there are still unsurveyed portions within the margins of the standard-sized sections.

The general maps of the Banda district on the 4-inch scale, which were remaining, have been completed and lodged; and one-inch maps of this district from drawings made in Calcutta are now under publication.

No. 4 REV. PARTY.

N. W. PROVINCES SURVEY



Photozincographed at the Surveyor Generals Office, Calcutta.

Published under the direction of Lieut. General J.T. Walker, C.B. R.E. F.R.S., Surveyor General of India.

Surveyor Generals Office, Calcutta, January 1883.

128. The Deputy Surveyor-General inspected the office of the party at Nainital during October. He considers that Colonel Anderson is deserving of great credit for the readiness with which he has set himself to acquire a knowledge of the new duties connected with writing the village khasras, and for the manner in which he has instructed his establishment in the new work required of them.*

XVIII.—DISTRICTS GHAZIPUR, BALLIA, AND BENARES, NORTH-WEST PROVINCES (No. 4 PARTY, REVENUE BRANCH).

129. The field operations of this party were resumed under control of Major Barron on 25th October 1881, and were continued up to 10th April 1882. During the season the cadastral survey of district Ghazipur has been completed, and that of district Ballia continued. The scale of cadastral survey has been 16 inches to a mile, except in the case of a few villages in Ballia, where the scale was increased to 32 inches to a mile on account of the very small size of the fields.

Personnel.

Major W. Barron, Deputy Superintendent, 3rd grade, in charge.
Mr. W. A. Wilson, Surveyor, 3rd grade.
„ H. T. Hanby „ 4th „
„ W. C. Price „ 4th „
„ S. C. Madras, Assistant Surveyor, 1st grade.
„ W. D. Corbett „ „ 1st „ transferred to No. 5 party with effect from 1st October 1881.
Mr. E. B. M. Drew, Assistant Surveyor, 3rd grade.
„ L. F. Berkeley „ „ 3rd „
30 sub-surveyors and others.

Temporary Establishment.

200 field surveyors and others.

130. The party has also been engaged on the survey, on the 4-inch scale, of a line of villages in district Shahabad of Bengal, on the banks of the Ganges, opposite to district Ghazipur. This work has been undertaken, on account of the Government of Bengal having determined to take advantage of the cadastral survey progressing along the Ganges and Gogra rivers, to have a line of river villages in districts Shahabad and Sarun surveyed simultaneously, so that the entire breadth of low-lying country, over which the above rivers are liable to flow, may be represented with full details of the boundaries of villages and estates in one series of maps for both provinces. A survey of this nature for all large rivers was sanctioned by the Government of India, Revenue and Agricultural Department, by letter No. 103, dated 3rd September 1881, to the Surveyor-General.

131. The separate areas surveyed in the different districts and on the different scales are shown in the following statement:—

District.	Description and scale of survey.	Number of villages.	Area in square miles.	Remarks.
Ghazipur	Cadastral: 16-inches to a mile.	664	224·58	Twenty-five villages in district Ballia, in area 4·15 square miles, were surveyed on the 32-inch scale.
Ballia	Ditto ...	1,177	409·98	
Total of cadastral survey ...	.....	1,841	634·56	
Shahabad	Mouzawar: 4-inches to a mile.	66	30·79	

An overlap of 12·50 square miles has been surveyed in district Azamgarh on the 2-inch scale. In the cadastral area, 9,88,157 fields have been surveyed, having an average area of ·41 of an acre. Preparatory traverse work has been extended over 162 square miles in the Ballia district, and the Benares district having been assigned to the party for cadastral survey, under authority of Government, North-Western Provinces and Oudh, conveyed in letter No. 93, dated 20th January 1882, preparatory traversing has been carried out in that district extending over 179 square miles.

132. In the cadastral survey, the system of plotting the field measurements directly on the skeleton maps of the traverses, without recording the measurements in field books, continues to work most advantageously. The work is done more rapidly than under the former system of keeping field books, and the same standard of accuracy is maintained. The usual checks and tests have been carried out, both by inspections of the work in progress and by subsequent

* Colonel Anderson reports very favourably of Messrs. Little, Shaw, Hill, and G. D. Smart.

comparisons of measured test lines. Of the latter, 567 linear miles were measured by the European staff, and 1,186 miles by Native inspectors.

133. The permanent marking of theodolite stations has been carefully attended to. At every station—there are 11,398 in the season's work—a pottery cylinder has been imbedded, at an average cost of 3 annas 7 pie per station. These marks are in addition to the stone marks which are placed at the trijunctions of village boundaries under the authority of settlement officers and at the expense of land-owners. Connections have been made with five stations of the Great Trigonometrical Survey, and the chain measurements of the traverses have been adjusted to agree with trigonometrical distances. The average error of the chaining was found to be 2·73 feet per mile. Azimuth observations were taken at 50 traverse stations, at an average distance of six miles apart.

134. The area surveyed cadastrally has been mapped on 1,323 sheets, of which, on 1st October, 977 sheets had been sent to Calcutta to be printed. There are nine standard-sized sheets of the 4-inch survey of the Ganges river villages in district Shahabad, on which a line of villages on the Ghazipur side of the river has been introduced by reduction from the cadastral maps, so as to represent the entire low-lying area in one projection. The general maps on the 2-inch scale of Ghazipur and Ballia are under preparation, nine having been finally completed and 20 partially drawn. On these sheets, the survey of parganas Bhadaon and Sikandarpur (now of Ballia, but formerly of district Azamgarh, and cadastrally surveyed in 1874–76), is being introduced, so that the map of district Ballia may be complete. A reduction of the maps of district Ghazipur to the scale of the Atlas of India has nearly been finished.

135. It is expected that the party will complete the survey of district Ballia and of the riverain villages on the Ganges and Gogra during 1882-83. District Benares will occupy season 1882-83 and part of season 1883-84, and a new district will be required to be allotted to give sufficient work to the party for the latter season.

136. The recess office of the party was inspected by the Deputy Surveyor-General at Naini Tal during October. The work of the party in all its branches was found to be highly satisfactory, reflecting great credit on Major Barron's skill and close supervision.*

XIX.—HANTHAWADDY DISTRICT, BRITISH BURMA, AND ARAKAN WASTE LAND GRANTS (No. 2 PARTY, REVENUE BRANCH).

137. This party has been under the charge of Major J. R. McCullagh, R.E., throughout the season.

Personnel.

Major J. R. McCullagh, R.E., Deputy Superintendent, 4th grade.
Mr. E. J. Jackson, Assistant Superintendent, 1st grade, returned from furlough and transferred to No. 2 party on the forenoon of 5th December 1881.
Mr. F. Grant, Surveyor, 2nd grade.
„ D. A. King, Officiating „ 4th „
„ J. McHatton, Assistant „ 1st „
„ G. E. Parker „ „ 2nd „
„ J. Murphy „ „ 2nd „
„ B. M. Wilson „ „ 2nd „
32 sub-surveyors and others.

Temporary Establishment.

135 field surveyors and others.

Leveling.

Mr. Fredric Roncontre, leveler, transferred to professional native establishment of No. 2 party from 1st November 1881.
Mr. Alexander Munro entertained as leveler from 1st November 1881.
Mr. Frank Roncontre entertained as leveler from 1st November 1881.

Small field parties were employed in the Rangoon town district during October and November 1881, and the cadastral field work was resumed in the Hanthawaddy district on the arrival of the field establishments from India during the early part of December. Field operations were continued up to the end of May.

138. The cadastral survey has chiefly been carried on in the Pegu and Hmawbee townships. In Angyee township the contouring of a small area of high land, remaining over from last season, has now been completed; and the field work of the cadastral survey of the Rangoon town district has been finished. Adjoining the Pegu township, a tract of country along

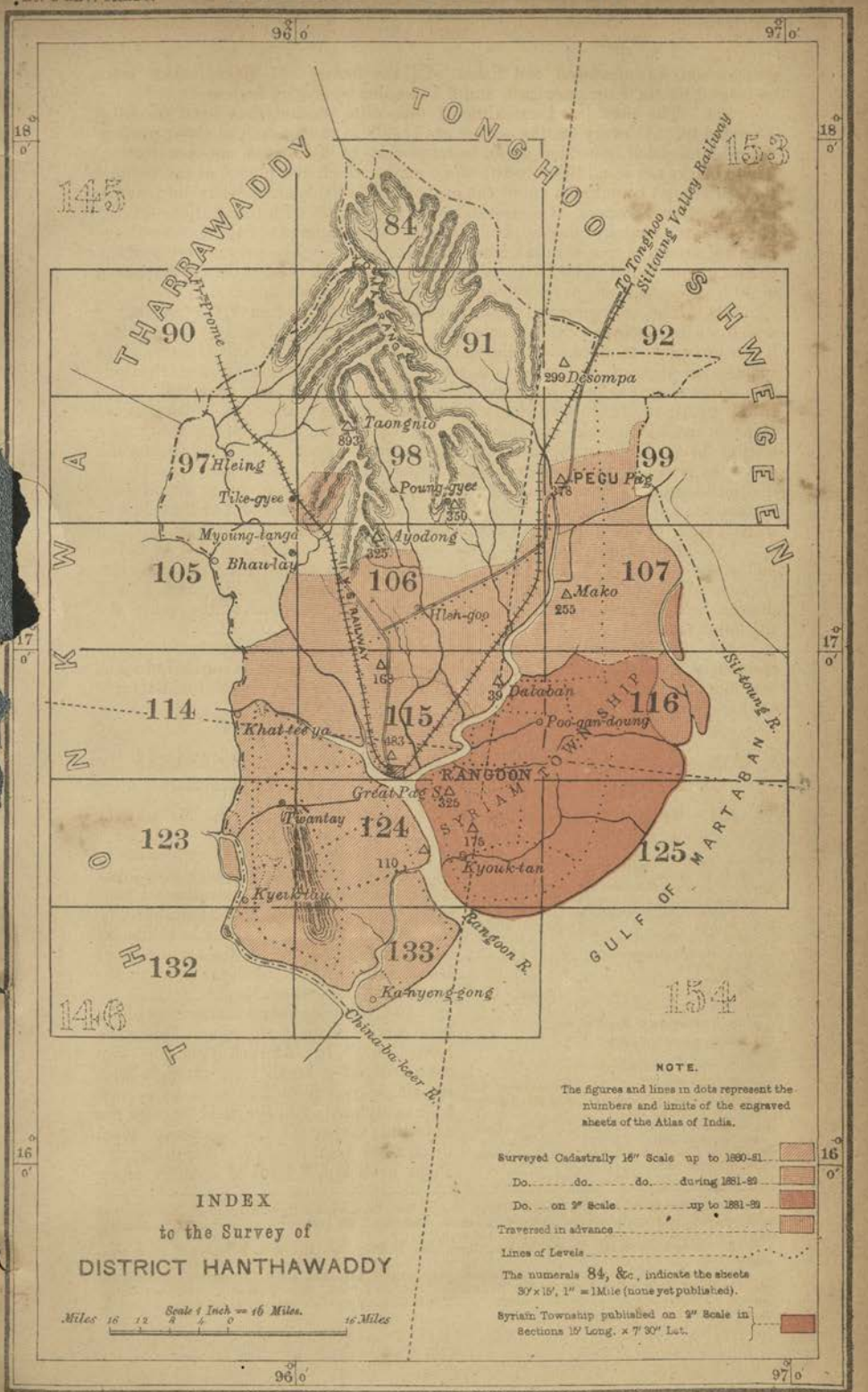
* Major Barron reports that Messrs. Wilson, Hanby, and Price, respectively in charge of three sections of his establishment, have conducted their duties to his entire satisfaction. He says:—"They are zealous, hardworking surveyors, and aim at turning out a high standard of work."

The assistant surveyors, Messrs. Madras, Drew, and Berkeley, are said to have performed their duties satisfactorily.

The following members of the native establishment are reported to have done well and to deserve commendation, viz. Ibu Hasan, Jamaloodeen, Mahmood Bux, Enayetoollah' Bhawani Pershad, Meer Ujudallee, Lalmohana Gungopadhya, Sew Narain, Kanaya Lall, and Zakirally. The rest of the members of the professional and cadastral establishments have worked well and heartily.

No. 2 REV. PARTY.

BRITISH BURMA SURVEY



NOTE.

The figures and lines in dots represent the numbers and limits of the engraved sheets of the Atlas of India.

Surveyed Cadastrally 16" Scale up to 1880-81.

Do. do. do. during 1881-82.

Do. on 2" Scale up to 1881-82.

Traversed in advance.

Lines of Levels.

The numerals 84, &c., indicate the sheets 30' × 15', 1" = 1 Mile (none yet published).

Syriam Township published on 2" Scale in Sections 15' Long. × 7' 30" Lat.

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to the Survey of

DISTRICT HANTHAWADDY

Miles 16 12 8 4 0 16 Miles

Scale 1 Inch = 16 Miles.

Photozincographed at the Surveyor Generals Office, Calcutta.

Published under the direction of Lieut-General J.T.Walker. C.B.R.E.F.R.S. Surveyor General of India.

Surveyor Generals Office. Calcutta, January 1883.

the sea-coast, devoid of cultivation and covered with *kain* grass and jungle, has been surveyed topographically on the 2-inch scale. A commencement has been made on the survey of the forest reserves in Hanthawaddy. The several areas are shown in the following statement:—

District and Township.	Area in Square Miles.		Remarks.
	16-inch scale.	2-inch scale.	
Hanthawaddy ... { Pegu, Hmawbee, and Twantay ...	739·5	91·7	
Hanthawaddy ... { Forest reserves	4·5	.....	
Rangoon Town district	19·5	.....	
Total	763·5	91·7	

In addition to the above, preparatory boundary traversing for the cadastral survey of next season has been done over an area of 458 square miles in the Pegu and Hmawbee townships, and 42 square miles of forest reserves have also been traversed in preparation for next season's survey.

139. A small sub-party of field surveyors under an assistant surveyor is now regularly organized as a section of this establishment set apart for the duty of carrying out the revisions of the maps of the previous season, so as to bring them into accord with the settlement papers, which are prepared one year subsequent to survey. During the season 719 square miles were brought under settlement, and the revisions were completed over the whole area, the work (which involves frequent references between the two departments) having been greatly facilitated by an arrangement for locating the Assistant Surveyor in the Settlement Officer's camp. On the subject of the revisions, Major McCullagh reports:—

"Revisions are due to the following causes:—

"1*st*.—Errors of survey; that is, faulty measurements or incorrect inking up.

"2*nd*.—Changes in the boundaries of fields and kwins.

"3*rd*.—Imperfect or indistinct demarcation, especially of garden lands.

"4*th*.—Extensions of cultivation.

"I have endeavoured to ascertain the percentage under each of the above heads, but unfortunately the rolls kept up have not enabled me to do so very accurately. The percentage of errata is calculated on the number of fields, and does not in any way represent area. It has been found to vary very considerably in different circles; the maximum being 30 per cent in Tawkoo, and the minimum 6 per cent in Kyouk Choung. The average for the 11 circles is 15 per cent; and of this I think it may be approximately taken that the figures 1, 5, 5, and 4 represent respectively the proportion of fields revised under the four different headings. The actual area of the cultivation opened out between the time of survey and settlement (extensions) amounts to 11,881 acres, or 18½ square miles."

140. The greater part of the area cadastrally surveyed in the Pegu township consists of an open cultivated plain requiring no particular description; but it included a strip of high-land (*kondan*) in which the cultivation and garden lands were difficult and tedious to survey, and a belt of country on the western margin, where unusually small fields, averaging about 7 to the acre, were met with. In the Hmawbee township, the greater part of the area likewise consisted of open country, chiefly under rice cultivation; but a very considerable extent of *kondan* was surveyed, where (to quote from Major McCullagh's report) the—

"ground is much broken and undulating, and for the most part covered with valuable gardens. The general appearance is that of heavy forest until examined more closely, when the trees are found to be fruit-bearing, with dense garden cultivation underneath. The boundaries of the gardens are very irregular, and have to be measured right round. Where rice cultivation extends up into the kondan, the fields are also irregular and very small."

141. The permanent demarcation of kwin boundaries has been effected by the survey establishment in the usual manner, by means of pottery cylinders imbedded at the theodolite stations. As a rule, the cylinders are not more than half a mile apart, but in many places, where the boundaries are irregular, they are much closer; pottery cylinders are also imbedded at certain selected stations in the interior of kwins.

142. The field survey has been carefully tested by check lines, amounting in the aggregate to 499 linear miles, measured by the European officers and by

the Native inspectors. All the stations of the Great Trigonometrical Survey lying within the area under survey have been connected with the traverses, and the direct trigonometrical distances have been used to correct the errors of the chain measurements. The angular work of the traverses has been checked by observations for azimuth at 36 stations. The number of fields surveyed is 5,09,763, showing a large increase on the number of former seasons, and giving a diminution of the average size of the field from 1·4 acres of last year to ·93 acre for the present season.

143. A large number of Burmans have been employed in different situations, but it has been found extremely difficult to keep up anything like a fixed establishment of Burmans, owing to the constant drain on the party for men to fill other situations.

Major McCullagh says of the Burmans:—

"A few of the field surveyors have done remarkably well, but on the whole they have not come up to my expectation, and there are many of them decidedly indifferent. My predecessor, Major Sandeman, bestowed such unqualified praise on the Burmans in their capacity as surveyors, that I may have been led to expect too much; but certainly my short experience tends to a conclusion much less favourable than his. The Burmans have some good qualities; they are quick, cheerful, and willing at learning, and, when under supervision, are fairly industrious and painstaking; but they have little idea of submission to discipline, and are wanting in habits of method and order: and let the eye of authority be taken off them, they are up to quite as many tricks, and just as much scheming, as any other race I am acquainted with. It appears to me, of course with some exceptions, that it is with them a case of time service. They have no love for the work, and take no real interest in it as a means of earning a livelihood or of gaining a name. The survey is a stepping stone to something else; and as long as they can do enough to qualify for a certificate, the aim and object of their service is satisfied. I am fully aware how much importance is attached to the policy of training Burmans in the profession of surveying, and I have endeavoured to carry out the views of Government to the utmost of my ability; but I must confess to feelings of disappointment, after all the care and attention bestowed, the large sums expended, and the many inducements held out to really deserving men, that the results are not more satisfactory."

144. The 16-inch sheets, 1,007 in number, of the area where the settlement and revision survey operated, were all sent to Calcutta to be photozincographed between 14th March and 21st July, after the revisions were entered. Photozincograph copies have been supplied to the district authorities.

145. The drawing of 860 new cadastral sheets surveyed during the season has been completed, and manuscript tracings have been given for the ensuing season's settlement operations. Of the general maps of the Hanthawaddy district, four sheets in 11 sections, comprising country surveyed cadastrally during previous seasons, have been completed and photozincographed. Several others are partially drawn, and the drawing is being continued as photozincographs of the cadastral sheets are available for reduction.

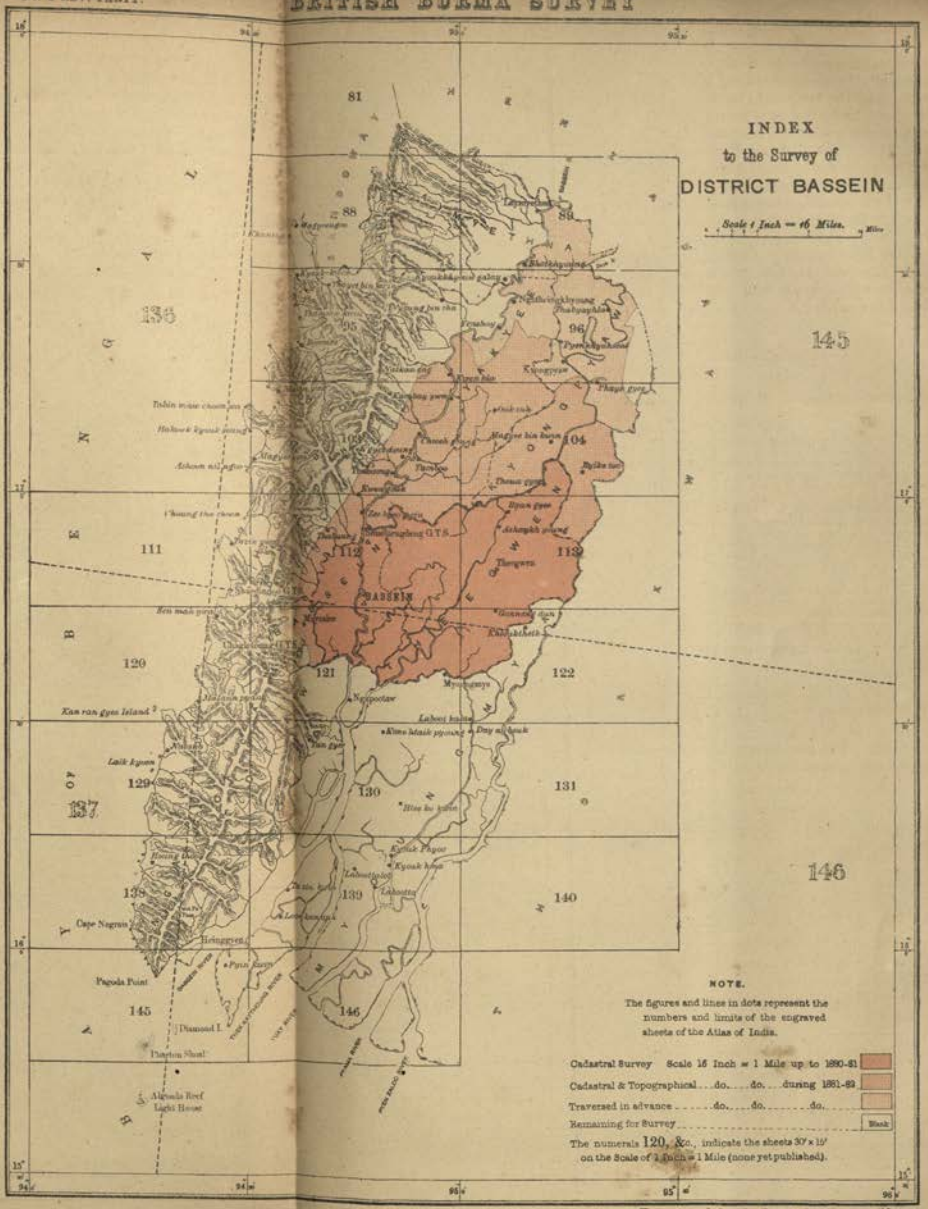
146. The detachment of this party which had been employed, during season 1880-81, in the Akyab district, surveying the boundaries of waste land grants, returned to Arakan in November 1881 for the purpose of carrying on the boundary survey of the remaining grants. Mr. H. Dowman was again sent in charge, and was furnished with an establishment partly from India and partly from Burma. The grants for survey lay in three districts, viz.—

	Grants.
Akyab	1
Kyouk-Phyoo	7
Sandoway	2
Total ...	10

On the completion of the survey of these in February 1882, Mr. Dowman was prepared to take up the adjustment of the boundaries of such of the grants surveyed during the previous season as might have been found on settlement investigation to have excessive areas; but the settlement investigations had not been carried out (an officer not having been available for the duty), and it was determined to employ the detachment during the remainder of the season, in rendering the existing demarcation more permanent than at first provided. This second demarcation was taken up too late in the year to allow of all the grants being done, and 54 only had been completed when the setting in of the

No. 8 REV. PARTY.

BRITISH BURMA SURVEY


INDEX
to the Survey of
DISTRICT BASSEIN
Scale 1 Inch = 16 Miles.
BASSEIN
NOTE.
The figures and lines in dots represent the numbers and limits of the engraved sheets of the Atlas of India.
Cadastral Survey Scale 16 Inch = 1 Mile up to 1880-81
Cadastral & Topographical ... do. ... do. ... during 1881-82
Traversed in advance ... do. ... do. ... do.
Remaining for Survey ... Blank
The numerals 120, &c., indicate the sheets 30' x 15' on the Scale of 1 Inch = 1 Mile (none yet published).
Cape Negrais
Pagoda Point
Diamond I.
Preparis Shoal
Alguada Reef Light House
Negrais
Myaungmya
Kyauk Pyoo
Labutta
Kan ran gyee Island
Laik kyoon
Pyin Salu
Thayet gyee
Thayet myo
Kyauk hlaing
Ngapudaw
Kyauk Phyoo
Hinggyee
Pyin Sarpi
Laboutta
Kyauk hnee
Kyauk Pyoo
Laik kyoon
Kan ran gyee Island
Myaungmya
Laboot hnaing
Nyapotaw
Kyauk hlaik pyoung
Day ni hnaik
Hlaing
Hlaing
Hlaing

rains put a stop to the work. Before the detachment left Akyab, Mr. T. C. Mitchell, Settlement Officer, arrived there and commenced his investigations regarding the areas held by the grantees. Consequent on these investigations, the boundaries can now be made final, and the detachment under Mr. Dowman will return to Arakan next season to aid in the permanent demarcation.

147. The British Burma Government maintains a survey school at Rangoon in connection with the survey party, over which Major McCullagh has exercised a general superintendence.

Two squads of levelers are attached to the party, whose work is reported on with the other leveling operations of the department. See page 56.

148. The office of the party at Rangoon, and one of the field camps in the Hanthawaddy district, were inspected during April by the Deputy Surveyor-General, who reports very highly on the style of the work which was being executed and of Major McCullagh's excellent management of his establishment.*

XX.—BASSEIN DISTRICT, BRITISH BURMA (No. 8 PARTY, REVENUE BRANCH).

149. Major W. H. Wilkins received charge of this party at Rangoon on the 25th November 1881 from Major E. H. Steel, on the departure of the latter officer on medical leave to Europe. The office establishment of the party, which had recessed at Rangoon, proceeded to Bassein during the first week in December, on the arrival of the field establishments from India, and cadastral operations were resumed in the Bassein district on the 10th December. The party remained in the field until the 27th May 1882, and then returned to recess quarters in Rangoon.

Personnel.

Major E. H. Steel, Assistant Superintendent, 1st grade, in charge up to 24th November 1881.
Major W. H. Wilkins, Deputy Superintendent, 3rd grade, in charge from forenoon of 25th November 1881.
Mr. H. R. Littlewood, Surveyor, 3rd grade.
„ J. H. O'Donel „ 4th „ transferred to Deputy Surveyor-General's office from 1st April 1882.
Mr. R. B. Smart, Assistant Surveyor, 1st grade, transferred from No. 5 party from 1st November 1881.
Mr. T. H. Dunne, Assistant Surveyor, 1st grade.
„ E. J. Martin „ „ 1st „ transferred from No. 6 party from 1st October 1881, transferred to No. 7 party from 1st November 1881.
Mr. W. H. Penrose, Assistant Surveyor, 2nd grade, transferred from No. 11 party from 1st November 1881.
Mr. G. Campbell, Assistant Surveyor, 2nd grade, rejoined from furlough and transferred to No. 1 party, Hissar District Survey, from afternoon of 21st September 1882.
Mr. C. W. J. Ford, Assistant Surveyor, 2nd grade.
„ W. H. D. Ewing „ „ 3rd „
28 sub-surveyors and others.

Temporary Establishment.

170 field surveyors and others.

150. The survey has been done entirely on the 16-inch scale, and the completed area is shown in the following statement, viz.—

Township.	Area in square miles.	Remarks.
Thaboung	378·6	
Kyon-Pyan	334·4	
Yay-gyee	99·7	
Total ...	812·7	

In addition to the above, boundary traversing has been done over an area of 350 square miles in preparation for cadastral survey next season. The number of fields in the cadastral area is 3,49,790, of an average size of ·44 acre calculated on the cultivated area, and of an average size of 1·49 acres calculated on total area.

* The following are extracts from Major McCullagh's report on his assistants :—
"Mr. Jackson, Assistant Superintendent, has a thorough knowledge of the work in all its details, and he has cheerfully and ably assisted me in every way."
"Messrs. Grant and King, in charge of cadastral camps, have shown much tact and judgment in the discharge of their onerous duties. I am much indebted to both for * * * the energy and endurance they have displayed."
Mr. Dowman is spoken of as an experienced, careful, and painstaking officer, who carried out the duties entrusted to him with much ability.
"Mr. McHatton, in charge of the revision camp, had very arduous duties to perform, into the execution of which he brought sound judgment and excellent temper to bear."
"Messrs. Parker and Murphy gave great satisfaction ; they are both hard-working and painstaking assistants."

151. The tract surveyed includes a very large area of waste land mixed up with the cultivation, as has been the case with the tracts previously brought under cadastral survey in Bassein, the separate areas for the present season being 240 square miles of cultivation and 573 square miles of waste. Major Steel, who held charge of the party during the previous season, gave much attention to the question of the survey of these large waste areas, in view of the fact that the survey of waste land brings no direct profit to Government; and, with the object of reducing expense, he proposed to the Chief Commissioner that the survey of the waste land should be done on the 2-inch scale, separately from the cultivation. The scheme being approved of by the Chief Commissioner, Major Wilkins introduced the system of separate surveys on the different scales of 16 inches and 2 inches at the commencement of the field season; but he did not maintain it for long, as, on account of the cultivation permeating through all parts of the waste, he found in practice that a complete survey, done in one operation on the large scale and mapped on one series of sheets, was more expeditious than the proposed system of omitting the details of the waste from the large scale survey, to be done in a subsequent operation on another series of sheets.

152. The revision survey in the area surveyed during the previous season, to bring the maps in accord with the settlement papers, was a very laborious undertaking, and added largely to the work of the party, one assistant surveyor and about one-fifth of the entire establishment of field surveyors having been exclusively employed on the revisions throughout the field season. The work included the determination of the boundaries of 908 parcels of *pottah* lands, situated, in many instances, in the heart of the jungle, the existence of which was brought to light during settlement investigations.

153. The preliminary and temporary demarcation of *kwin* boundaries has, as usual, been done in advance of the survey by the district authorities, and the permanent demarcation by the survey party. For permanent marks, the pottery cylinders of the previous year have again been used; those have been imbedded at two out of three theodolite stations on the *kwin* boundaries, and, for use as reference marks when extensions in the cultivation have to be mapped, at many stations in the interior of the *kwin* lands. About one-fourth of the field surveyors of the establishment employed last year were Burmans. It is not advisable to employ Burmans in a large proportion, as the work of these men is slow—they do less than a third of the average monthly outturn of the Hindustanis—and consequently costly. Major Wilkins has taken great interest in the Burmans of his establishment, recognising the great importance of the professional survey leaving in the district a school of trained surveyors; but he expresses disappointment in his experience of these men after what he had been led to expect of them, and he states that the praise bestowed on the Burmans in last year's report cannot be given this year.

Major Wilkins also writes:—

"It is greatly to be regretted that a few Burmans have not been found able to become qualified to undertake an inspector's duties, for such men would be invaluable in teaching other Burmans. * * * * * * *

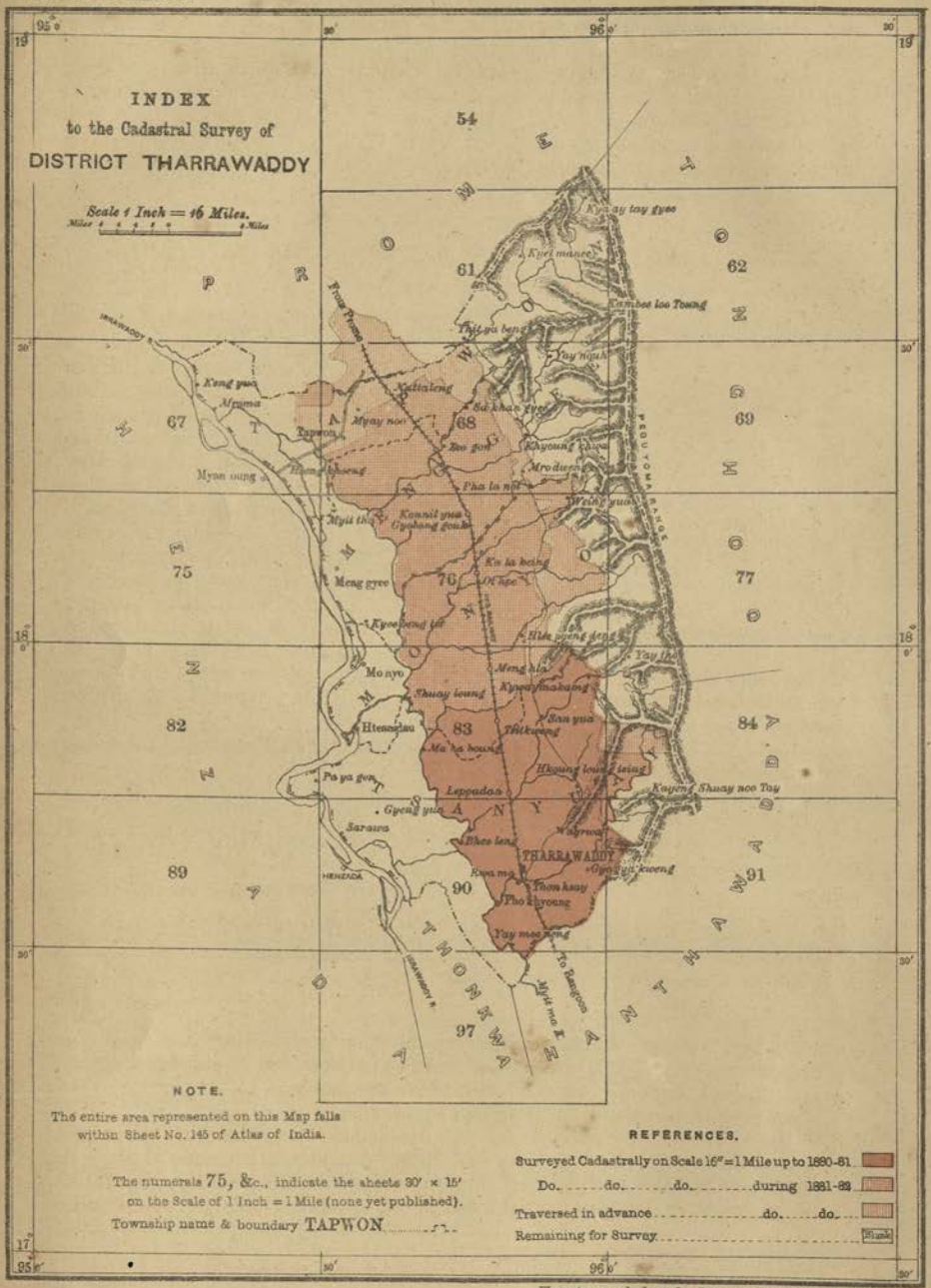
If two or three suitable Burmans can be found, endeavours will be made to train them for the post of inspector, and, by the offer of a liberal salary, to restrain them from leaving the department. At present, the hope of getting other employment is the only inducement for a Burman to become proficient in the various duties of a cadastral surveyor. To train himself for the duties of an inspector or general surveyor, so that he can impart his knowledge to his fellow countrymen and become of real assistance to the European officers of a party, is not within the scope of his ambition."

154. A survey school in connection with the party has been kept up by the Educational Department in the town of Bassein, over which Major Wilkins has exercised a general supervision.

Major Wilkins reports that he and the European officers of the party constantly visited the field surveyors while they were working in the field, to see that they were surveying on correct principles. Check surveys, aggregating 909 linear miles, were also carried out in the most rigorous manner. Observations for azimuth to check the angular work of the traverses were taken at 64 traverse stations.

No. 7 REV. PARTY.

BRITISH BURMA SURVEY



Photozincographed at the Surveyor General's Office, Calcutta

Published under the direction of Lieut: General J.T. Walker, C.B.-R.E.-F.R.S., *Surveyor General of India.*

Surveyor General's Office, Calcutta, January
1883

155. The 16-inch sheets, 1,031 in number, on which the season's outturn has been mapped, have been drawn, and tracings have been supplied for the use of the Settlement Officer. The sheets of the previous season's area, where the settlement operations were conducted, have been completed in accordance with settlement investigations, and all were forwarded to Calcutta to be printed in time for the supplementary survey of the succeeding season. The general maps on the 2-inch scale are in progress.

156. The Deputy Surveyor-General visited the Bassein district during April, and inspected the camp offices of the party, besides examining some of the cadastral plans in the field. He expresses himself as having been well satisfied with the control exercised by Major Wilkins over all branches of his large establishment, and with the style of work which was being executed.*

XXI.—THARAWADDY DISTRICT, BRITISH BURMA (No. 7 PARTY, REVENUE BRANCH).

157. This party, under charge of Mr. H. B. Talbot, resumed cadastral operations in the Tharawaddy district on the arrival of the field establishments from India towards the end of November. Field work was continued until nearly the end of May, when the party returned to recess quarters in Rangoon.

Personnel.

Mr. H. B. Talbot, Assistant Superintendent, 1st grade, in charge.
„ W. R Vyall, Surveyor, 4th grade.
„ G. W. Jarbo, Assistant Surveyor, 1st grade.
„ J. R. Scott „ „ 1st „
„ J. S. Swiney „ „ 1st „ transferred from No. 6 party with effect from 1st April 1882.
Mr. E. J. Martin, Assistant Surveyor, 1st grade, transferred from No. 8 party from 1st November 1881, and on furlough from 1st April 1882.
Mr. A. W. Smart, Assistant Surveyor, 2nd grade.
„ D. J. Collins, „ „ 3rd „ transferred from the Darjeeling topographical party from 1st November 1881.
30 sub-surveyors and others.

Temporary Establishment.

165 field surveyors and others.

158. Besides the regular cadastral survey on the 16-inch scale, the party has surveyed, on the 2-inch scale, extensive tracts of waste land in the Irrawaddy Valley along the Myitmakha river, and has commenced the survey on the 4-inch scale, for the Forest Department, of the forest reserves of the Tharawaddy district, situated in the hilly tracts of the Pegu Yoma range.

159. The areas accomplished on the several scales are shown in the following statement:—

Township.	On 16-inch scale. Square miles.	On 2-inch scale. Square miles.	On 4-inch scale. Square miles.
Minhla	212	107	.....
Gyobingouk	229		.....
Tapoon	85	.....	.....
Thonzeh	.....	.....	42
Total ...	526	107	42

In addition to the above, preparatory boundary traversing has been done over an area of 276 square miles, partly in the Tharawaddy district and partly in the Prome district. An area of 25 square miles in the forest reserves of Tharawaddy has also been traversed in advance.

160. The survey of changes and extensions of cultivation in the area surveyed during the previous year and brought under settlement during the current year has also been carried out, involving, as reported by Mr. Talbot, very heavy work both in the field and in office. In the tract surveyed on the

* Major Wilkins has reported of all his assistants:—
"Mr. Littlewood (he says) is a first-rate assistant, who has his work always up to date, with a perfect temper and cool judgment that never desert him."
Messrs. O'Donel, Smart, Dunne, and Ford, who had charge of sections of the establishment, are highly reported on, and Mr. Penrose, as an assistant to the others, is said to have worked very satisfactorily.
The following sub surveyors and others are mentioned favourably by name:—
Sub-surveyors Sheikh Abdullah, Wazir Ali, and Koylas Chunder; draftsmen Rahim Bux, Shamsuddin and Gujadhar; and computer Manohar Lall.

16-inch scale a large amount of waste land has been found to be mixed up with the cultivation, the separate areas being 287 square miles of waste and 239 square miles of cultivation in the total area of 526 square miles. The number of fields in the cultivated area is 4,95,000, giving ·30 acre as the actual average size of each field calculated on the cultivated area, and ·68 acre as the average size if calculated on the total area.

161. The permanent demarcation of *kwin* boundaries has been carried out by the survey party, the marks adopted being pottery cylinders imbedded at theodolite stations, the same as in the previous year. For the purposes of the supplementary survey, which will be carried on year by year to map the extensions of cultivation, marks have also been placed at stations in the interior of the *kwins* as well as on the boundaries. In the forest reserves, the theodolite stations have been marked by posts and mounds of earth, zinc numbers in Burmese characters being nailed to the posts.

162. The survey of the forest reserves has been undertaken in accordance with the wish of the Chief Commissioner, expressed in his Secretary's letter No. 406—9, dated 13th October 1881, to the Surveyor-General. The nature of the country presented many difficulties to the surveyors, the difficulties being increased by the position of the reserves, which are situated in an almost uninhabited country, far removed from the cultivated part of the Tharawaddy district. Supplies had to be sent from a distance; and in the reserves, special arrangements had to be made for carrying water for the use of the survey squads. Sickness also was very prevalent; generally 20 per cent. of the men were unfit for work, and very often 30 per cent. The reserved tract consists of an intricate mass of hills, with many minute features, and closely jungle clad, where a ray had to be cleared for every line that was measured. A few descriptive notes furnished by Mr. G. W. Jarbo, Assistant Surveyor, who was directly employed on the survey of the tract, are printed at page 31 of the appendix.

163. Mr. Talbot reports as follows on the Burmans of his field establishment:—

"The work of the Burman field surveyors was generally found correct, and they certainly hold their own against the Hindustani surveyors as far as accuracy is concerned; but they are lamentably slow, and require far greater supervision. The 35 Burman field surveyors employed during the whole of the field season gave less than half the daily average of work performed by Hindustani surveyors, viz.—

	Acres per day.
Burmans	12
Hindustanis	28

which was a loss of 480 acres per man per month, or 144 square miles in the season's outturn."

At the request of the Chief Commissioner, six Burman apprentices were attached to the topographers employed on the survey of the forest reserves for instruction in topographical surveying. These men could only be induced to join by the offer of high subsistence allowances; and the experiment of training them has not been very satisfactory, as, it is said, the men will not take employment as forest surveyors, which was the object of their being instructed. The work of the field surveyors was carefully tested by the measurement of 1,010 linear miles of check lines carried out by the European officers and by Native inspectors. The European officers also frequently inspected the field survey work during its progress. The traverses have been connected with seven stations of the Great Trigonometrical Survey, and the trigonometrical distances have been used to correct the errors in the chain measurements. Observations for azimuth have been taken at 61 traverse stations.

164. The present season's out-turn of 16-inch survey has been mapped on 660 sheets, of which tracings have been furnished for the use of the settlement officer in his operations of next season. The sheets of the previous season have been finally completed after entering the revisions and extensions, and they were sent to Calcutta to be printed in time for the settlement operations of the following season.

165. The office of the party in camp in the Tharawaddy district was inspected during April by the Deputy Surveyor-General, who expresses himself as having been well satisfied with the careful supervision exercised by Mr. Talbot over his large establishment.*

XXII.—SYLHET TEST SURVEY.

166. This survey has been carried out under the instructions of the Government of India, Home, Revenue, and Agricultural Department, conveyed in the Officiating Secretary's letter No. 445, dated 18th December 1880, to the Surveyor-General, for the purpose of testing the *mahalwar* maps of the Sylhet district, which were prepared by a local survey establishment during years 1862 to 1864.

167. The detachment of surveyors and others required for the limited area to be surveyed was furnished by No. 6 party of the Revenue Branch, and Mr. P. A. G. Cowley, Surveyor, 2nd grade, of the same party, was placed in immediate charge of the detachment. The field establishment assembled at Barrackpore on the 1st November 1881, and the detachment was finally broken up at the same station on the 25th June 1882, after completion of the mapping and area calculations. The actual field work in Sylhet was carried on between 23rd December 1881 and 23rd April 1882.

Personnel.

Mr. P. A. G. Cowley, Surveyor, 2nd grade, in charge from 1st November 1881 to 25th June 1882.
4 sub-surveyors and others.

Temporary Establishment.

17 field surveyors and others.

168. Before commencing the operations, it was necessary to decide on the amount of survey work which should be done in connection with the testing. A mere testing of what is shown on the mahalwar maps would have been effected by resurveying only the boundaries of mahals, besides which no other divisions subordinate to villages were dealt with by the mahalwar survey; but a mahalwar survey, where the mahals are large, is a work of a very partial character, and wanting in information regarding many minor tenures. Therefore it was deemed to be advisable that the present operations should not be restricted to the mere skeletons of mahals (more specially as the surveyors who were being sent to Sylhet were well competent to carry out a much more comprehensive work, having been previously employed on cadastral surveys in the North-Western Provinces); and in consultation with the Chief Commissioner of Assam it was decided that the testing operations should take the form of a complete cadastral survey of fields, with which the boundaries of mahals would also be defined in a distinguishing manner. It was also decided that the operations should be confined to three blocks of villages in different parts of the Sylhet district. The particulars of the blocks (which were selected by the Deputy Commissioner of the district) are given in the following statement:—

Sub-division.	Number of villages.	Area in square miles.	Remarks.
Karimganj	14	9·06	
Habiganj	20	8·30	
Sadr	16	8·40	
Total ...	50	25·76	

At the request of the Chief Commissioner, the surveyors were required to prepare, simultaneously with the survey, village registers (khasras), particularising (1) name of mahal, (2) owner of mahal, (3) name of cultivator of field, (4) nature of crop.

* Mr. Talbot reports very favourably of his assistants, Messrs. Vyall, Jarbo, Scott, and Smart. He also says:—

"The care and trouble bestowed by Mr. Scott in teaching the Burmans deserve much praise.

"Mr. Jarbo also deserves great praise for the steady way he conducted the forest reserve survey in the Pegu Yoma; though sick himself, he still worked on and set a good example to his men."

Messrs. Swiney and Martin are also said to have done well. The following members of the native establishment are said to deserve mention as having worked well, viz.—Venketsawmy, Nundlall Chatterjee, Soomair Singh, Shoshi Bhushan Ghosal, Issan Chunder Ghosal, and Mr. La Rive.

169. Before stating the results of the testing operations, a few remarks are desirable on the character of the maps which had to be tested. The mahalwar survey of Sylhet was done entirely by magnetic bearings, on a system adopted for all the districts of Lower Bengal after the old system of sketching without instruments had been abandoned. The first part of the operation was the survey of the village boundary—the *thakbust*—done by taking bearings at each successive bend of the boundary to the forward bend, and measuring the distances between the bends. The map was then projected by laying off the magnetic bearings at each successive distance. On completing the projection, it would generally happen, when the village was large, that the polygon would not close, and an adjustment had to be made by distributing the error all round the boundary. The mahals were then surveyed, working inwards from all sides of the boundary, by taking the bearings and measuring the lengths of the sides and diagonals, and adding the plot of each mahal to the one adjoining it. A frequent occurrence during the plotting of the mahals was that the plots from the different sides of the village would overlap, and an adjustment had to be made by contracting the areas of some of the mahals, or it might happen that the plots of mahals actually touching one another would not meet. These would generally be left as plotted, thus unduly expanding the size of other mahals. The general character of mahalwar maps prepared in the manner described is that the plots of the mahals situated on the boundaries of villages, and those to a certain distance towards the centre, are usually correct; but when the plotting from the different sides has met, the dimensions and shapes of mahals are usually inaccurate, and the relative positions are, as a rule, much vitiated.

170. The cadastral maps of the villages selected for resurvey have been plotted on the same scale as the mahalwar maps—16 inches to a mile. This has enabled the testing of the mahalwar maps to be done by direct comparison, tracings of these maps on vellum cloth being superimposed over the maps of the present survey, and the differences or coincidences noted. It is evident from the comparisons which have thus been made that a large amount of careful and laborious work was done during the mahalwar survey; and great numbers of mahals, very many of small size, are found to have been accurately measured, as is shown by the excellent agreement of numerous mahals in all the villages tested. But the agreement is for the most part only true when the superimposed tracings are shifted, so as to make single plots coincide; and there is found, mixed up with a great deal of good work, a very large amount of mapping which is most inaccurate,—so much that the survey cannot be considered to be otherwise than quite unreliable, and the errors being of such a character that there would be very great danger of the maps being most misleading if they were to be accepted as the final authoritative records of the positions or areas of properties. The differences between the present and former maps, which have hitherto been referred to, are those arising from faulty survey; but besides these, there are numerous differences, due to the changes in the boundaries of mahals, and occurring both by the amalgamation as well as by the subdivision of the mahals as these are shown on the former maps.

171. The areas of fields—and by summation the areas of mahals—have been calculated from the present cadastral maps, and comparisons have been made with the areas of the old mahalwar registers, with results similar in character to those obtained on comparing the two sets of maps. Where the mahalwar survey is accurate, the areas have been rightly calculated, and the agreement is excellent in a large number of cases; but there are also numerous and great discrepancies. Very many of the discrepancies in the areas are, however, due to the changes in the boundaries. One point which deserves to be prominently brought forward, as having been fully established by the present testing operations, is the unsuitability of the system of survey on which the mahalwar maps were constructed to deal with large village areas enclosing numerous subordinate plots. To secure a map on which all properties will be represented in their true positions and with correct dimensions, an accurate frame-work obtained by thedolite traversing must be provided.

172. There are 61 sheets of the cadastral survey of the tested villages; of these, 16 sheets have been photozincographed and copies furnished to the local Government of Assam, by whom the final report on the results of the

testing will be submitted to the Government of India. Comparative statements of mahal areas, according to present and former surveys, have also been furnished to the local Government.*

XXIII.—SURVEYS IN THE DARJEELING DISTRICT.

173. The existing map of the hill tracts of the Darjeeling district, lying west of the Teesta river, is mainly based on a survey which was executed during 1865-67 by a Revenue survey party under Mr. Johnson. This party had been previously employed solely in the plains, and it had no experience of hill topography. But at that time a survey of the boundaries of Government lands and of private estates, tea plantations and 'locations,' was urgently demanded by the local authorities for purposes of administration, and with a view to the future allotment of grants of waste lands. The party had had much experience of boundary survey work in the plains, and were well skilled in its performance, whereas, on the other hand, the topographical survey parties, which were well skilled in hill sketching, were not organised to undertake a large amount of boundary survey work in addition to topography. Thus the choice of the party devolved on the one which was best adapted to satisfy the immediate requirements of the local authorities.

Personnel.

Captain H. J. Harman, Assistant Superintendent, 1st grade, in charge.
E. C. Ryall, Esq., Offg. Assistant Superintendent, 1st grade.
Mr. J. A. May, Surveyor, 3rd grade (for portion of field season).
Mr. W. J. O'Sullivan, Surveyor, 4th grade.
„ W. Robert, Assistant „ 1st „
„ W. C. G. Barckley „ „ 2nd „ (for recess only).
Sub-Surveyor Sahai Din.
„ Bhowani.
„ Mahomed Khan.

174. As the boundary survey progressed, the principal roads and water-courses were traversed, and some attempt was made to sketch in the hill features broadly; but exact topography was unattainable with the existing agency, and was not attempted. The maps thus prepared were considered sufficient until latterly, when the operations of Captain Harman's party in surveying new boundary lines and relaying old ones, of which the original marks had disappeared, brought to light the necessity for the revision of the hill topography throughout, and for the rectification of some of the traverses, which having been carried over mountain slopes and precipices, and very difficult ground generally, and being unchecked by triangulation, were found to be erroneous.

175. These circumstances were brought prominently to the notice of the Bengal Government at Darjeeling by Major Hutchinson while residing there, when acting for Captain Harman during the recess of 1881. Consequently a requisition was made for the survey of the whole of the Hill Tracts west of the Teesta river to be revised as speedily as possible. Already a large amount of triangulation had been executed in connection with the recent operations under Captain Harman; this was extended to cover the whole of the area for revision; the old traverses were connected with, and adjusted on the trigonometrical points, and much of the detail of roads and water-courses of the first survey was found to fit in well with the new work. The hill sketching, however, had to be entirely revised. The 2-inch scale, which had been adopted for the first survey, was retained for the second. The total area for revision was about 450 miles.

176. During the field season all the requisite additional triangulation was completed by Mr. O'Sullivan; a considerable length of road was traversed with chain and compass by native surveyors, plotted on a large scale, and then reduced by pantagraph on to the plane-tables of the revisionary survey. The hill sketching was then proceeded with, and 155* square miles were completed. What remains for revision and hill topography should be completed in the next field season.

* By Captain Harman 24 sq. miles.
„ Mr. Ryall ... 94 „
„ Mr. May ... 87 „

177. At the commencement of the field season Captain Harman bravely endeavoured to reach the neighbourhood of the Kanchinjinga mountain, to complete a portion of the survey of Sikkim, notwithstanding that he had not by

* Mr. Cowley, from beginning to end of the operations, has carried on the work entrusted to him most satisfactorily.

any means recovered from the disastrous effects of his previous excursions to the snowy regions on the borders of Tibet But his health again failed him, and after a few weeks' struggle onwards he had to abandon the attempt and return from Sikkim, occupying himself for the remainder of the field season in the lower hill tracts around Darjeeling.

178. The prosecution of the survey of Sikkim with the adjoining portions of Nepal and Tibet has thus devolved almost wholly on Mr. Robert, who completed 180 square miles of East Sikkim, and in addition was able to survey and sketch with varying degrees of accuracy, on the ½-inch scale, upwards of 720 square miles of Nepal and 690 of Tibet.

179. During the recess the party was very fully occupied in completing the fair maps of the previous field season's work Of those sent into the Surveyor-General's office, the principal are—(1) Hill territory, British Sikkim in 4 sheets, scale 2 inches equal to 1 mile; (2) Terai Pergunnahs in 4 sheets, scale 2 inches equal to 1 mile; (3) Jotes in the Terai Pergunnahs in 9 sheets, scale 4 inches equal to 1 mile. Captain Harman has also sent in a most carefully executed panoramic profile of the great ranges of Sikkim, the point of sight being the observatory hill at Darjeeling. It is drawn to scale for horizontal and vertical distances: thus the bearings and elevations of the different peaks are shown. A table of distances of the principal points is also entered on the sheet. This panorama has been reproduced by photozincography for publication at the Surveyor-General's office, and it is in much demand by visitors to Darjeeling. Captain Harman has discovered that the mountain which is always pointed out from the neighbourhood of Darjeeling as Mount Everest is not that mountain, the true Mount Everest being that immediately to the left (or south) of the peak which generally passes for it.

180. Though repeatedly warned by his medical advisers to cease from working and take leave of absence for the benefit of his health, Captain Harman retained the charge of his party until the close of the recess, and then handed it over to Lieutenant-Colonel Tanner on the return of that officer from furlough. In the coming field season Colonel Tanner will supervise the completion of the revisionary operations in the Darjeeling Hill Tracts. But he will be principally employed in survey operations on the Nepal boundary for the purpose of carrying out a proposal made by the Resident in Nepal, and approved by the Government of Bengal, that the portion of the boundary between British and Nepal territory from Bikna Thori in Champarun to the point on the Kusi river in Bhagulpore where the survey of 1875 under Captain Samuels ended, should be resurveyed, and the boundary pillars and posts renumbered. While thus employed, Colonel Tanner will endeavour to fix, by triangulation, all the most prominent hill peaks in Nepal between the British frontier and the great snowy ranges. The chief peaks of the latter were long ago fixed by triangulation, but as yet this has not been done for the points on the lower ranges, and it is very necessary with a view to furnishing a satisfactory basis for constructing a better map of Nepal.

XXIV.—THE BURMA-MANIPUR BOUNDARY.

181. As mentioned in the report for last season, Major W. F. Badgley was deputed to the survey of part of the Burma-Manipur boundary, the demarcation of which was being undertaken by the Political Agent and Boundary Commissioner, Colonel Johnstone.

Personnel.

Major W. F. Badgley, S.C., Deputy Superintendent, 3rd grade, in charge.
Mr. M. J. Ogle, Surveyor, 4th grade.

182. Accompanied by Mr. Ogle, Major Badgley left Shillong on the 4th November, and after a tedious march through the hills and a delay of a week at Cachar owing to the difficulty of procuring coolies, reached Manipur on the 27th November. From this point Major Badgley carried forward a survey eastwards in the direction of Kungal thana, where Colonel Johnstone had established his camp, the triangulation and topography being carried on *pari passu*, as is necessary in such work.

183. After an unsuccessful attempt to open negotiations with the Burmese, Colonel Johnstone determined to send his Assistant Commissioner to Samjok

INDEX CHART
TO
SURVEYS OF NORTHERN AFGHANISTAN

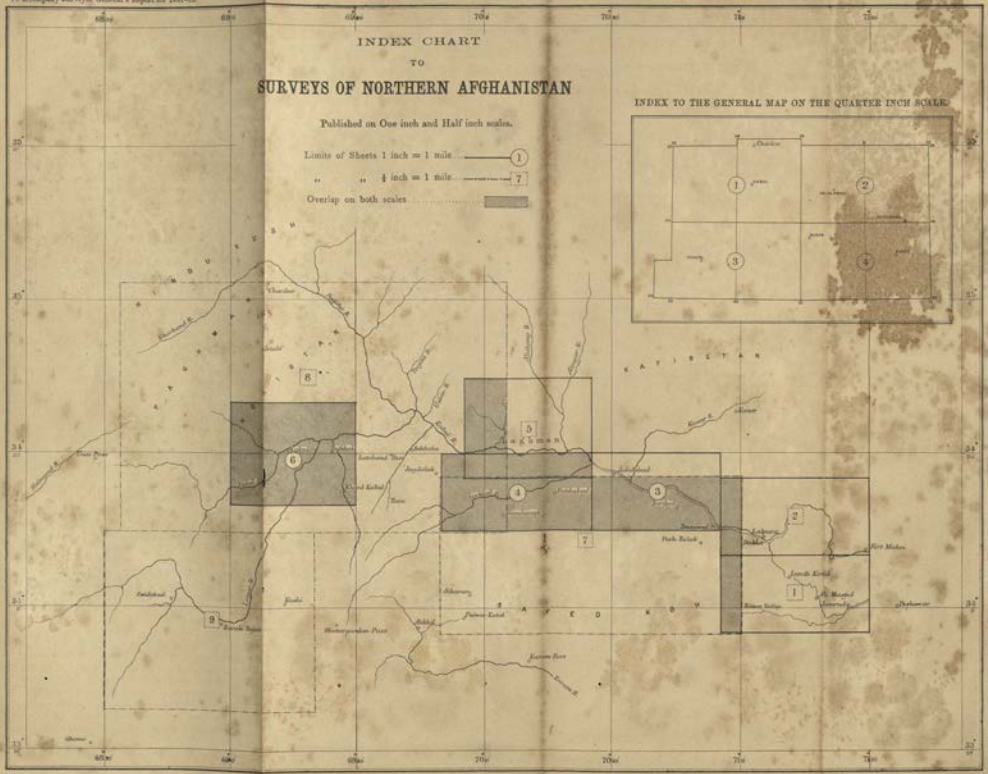
Published on One inch and Half inch scales.

Limits of Sheets 1 inch = 1 mile ——— 1

" " ½ inch = 1 mile ——— 7

Overlap on both scales .....

INDEX TO THE GENERAL MAP ON THE QUARTER INCH SCALE.



Published under the direction of Lieut. General J. T. Walker, C.B., R.A., F.R.S., Surveyor General of India,
at the Surveyor General's Office, Calcutta, January 1882.

to see the Rajah. Major Badgley accompanied Mr. Phayre on the expedition to this little-known spot—the easternmost point yet reached in the course of the survey operations—which is situated on the Kyendwen river, within the borders of Western Burma. His interesting description of the trip will be found in the appendix to this report. The boundary demarcation being completed by the 5th January, Major Badgley took advantage of his return journey to complete as much as possible of the survey of the Manipur territory. The ground sketched is a tract some 30 miles wide, extending roughly along the meridian of 94°30′E., and lying between the parallels of 24° and 25°30′.

XXV.—NORTHERN AFGHANISTAN.

184. No actual survey work was executed in this region during the current year, but considerable progress has been made with the final mapping of the surveys which were executed during the late war, and which have been described in the Annual Reports for 1878–81. Urgent calls for maps have been met hitherto by preliminary compilations. It still remained, however, to put all the geographical information which had been obtained beyond the British frontier into a form for final record, applying such corrections and adjustments as were required to harmonize the whole, and to bring it into accord with the many points now well fixed by triangulation, and, finally, to redraw all the maps, for as yet the fair copies had not in any instance been made. This work has been entrusted to Major Holdich and his party, who are thoroughly familiar with the country; and it has formed their chief occupation during the recess of the current year

185. The maps will be published in two series—firstly, a set of maps published on the same scale as that on which the surveys were originally executed. This will comprise a map of the country immediately round Kabul, on the scale of 4 inches to a mile, and maps on the 1-inch and ½-inch scales of such parts of Northern Afghanistan as were actually surveyed. Proofs of these maps will be taken as they are being passed through the press to be supplied to the Quarter-Master-General's Department for such additions as will tend to enhance their military value, when they are finally published. The second series will form a general map of North Afghanistan in four sheets on the scale of ¼-inch=1 mile. The publication of these is at present suspended to permit of Major Holdich and his party resuming field operations in the Kohat district. Happily, there is no urgent necessity for immediate publication, and the delay will probably admit of additional geographical information, derived from reconnaissances which are shortly coming to hand, being incorporated into the series of maps.

XXVI.—SURVEYS IN DARDISTAN AND ON THE KISHANGANGA.

186. Colonel Tanner having proceeded to Europe on leave of absence, Native Surveyor Ahmad Ali Khan, who had for some time previously been employed under him in the survey operations around Gilgit, described in previous reports, was placed under the immediate orders of Mr. Hennessey, and deputed, with a small party of attendants, to operate in continuation of what he had done under Colonel Tanner.

187. The summer—the season of field work in these regions, though of recess in India generally—was somewhat far advanced by the time the surveyor reached his ground, and shortly afterwards he became seriously ill and had to return to Sirinagar, in Kashmir, for medical treatment. Thus the duration of his field season was much curtailed. The work assigned to him was to visit the Kishanganga-Indus watershed, and from thence to sketch as much as practicable of the Dardistan country surrounding Chilás, which juts into Kashmir territory. No survey of this tract, which in shape somewhat resembles a horse-shoe, has yet been made, because the chief of Chilás views all foreigners with suspicion, and would be specially opposed to the admission of surveyors. But a sketch of its principal features, and of the passes leading into it, may probably be made from the summits of the mountains on the periphery of the horse-shoe, which is the border line separating this region

from the territories of Kashmir, and is thus accessible to Europeans. From various points on this line views may be obtained down into the valley of the river Indus, which lies at a considerable depth below, and passes through the middle of the horse-shoe.

188. Unfortunately, the winter had already set in when Ahmad Ali reached the Kishanganga-Indus watershed, so that the features of the view before him could not be separated, covered as they were all alike with the white snow. But he succeeded in sketching an area of about 200 square miles of new ground towards Chilás, and in fixing all the passes along the watershed; and he was, moreover, able to obtain a considerable amount of supplemental topography in an area of about 600 square miles in the basin of the Kishanganga river, the first survey of which—made in the year 1858, during the mutinies—was necessarily very sketchy and imperfect, and greatly needed revision and amplification.

XXVII.—TRANS-HIMALAYAN EXPLORATIONS.

1.—EXPLORATIONS IN AND AROUND BADAKSHÁN.

189. In the year 1877, M— S—, a Native gentleman of the Mahomedan faith, a Pír, or holy man, of much repute among his co-religionists—was about to make a journey from Kashmir, across the Hindu Kush range and the river Oxus, to Koláb, beyond Badakshan, to visit the shrines of his ancestors and transact some business of his own, when he learned from one of his friends, an employé of this department, that he might obtain employment in geographical exploration if he would volunteer his services and was willing to go through a course of training. His services were readily accepted, as he was a man of considerable intelligence and good education. He was brought down to the office in Dehra Dún, where he was put through a course of training under the veteran explorer Pandit Nain Sing. He then proceeded to his destination *viâ* Kâshmir, Gilgit, and Yasín, where he arrived on the 14th December 1878.

190. At Yasín he was hospitably received by Mír Pahlwan, the chief of the country and brother of Mír Wali, Mr. Hayward's murderer; but he was detained by his host on one excuse and another for nine months. At last on the 3rd September 1879 he was permitted to continue his journey. Proceeding up the Darkoth Valley, in which Hayward was murdered, he crossed the Shunder Pass and entered the head of the Mustauj Valley; then, crossing the Baroghil Pass, he entered the valley of Wakhán and struck the river Panjah, or Oxus, at Sarhad. From this place he followed the well-known route to Faizábád *viâ* Kila Panjah, Ishkásham, and Zebák.

191. It was his intention to have proceeded from Ishkásham down the valley of the Panjah river to Shignán and Darwáz, but there was enmity between the rulers of these two states, and entrance into Darwáz from Shignán was prohibited. He could not therefore reach Koláb by that route, but was obliged to proceed *viâ* Faizábád. Here he was detained for two months, while the road to Rusták was closed by the then ruler of Faizábád, Sháhzáda Hasan Khán, who was at war with the ruler of Rusták.

192. When peace was temporarily re-established, M— S— started again; but the road to Rusták being still considered unsafe, he made a diversion to the south, to the Daraím Valley, which he ascended until he reached the watershed separating it from the valley of Jirm. Towards the end of February he was able to continue his journey to Rusták and Koláb. From Atan Jalab he followed the route previously taken by the Havildar. At Koláb he left the Havildar's route and proceeded up the Doába Valley as far as Robát, beyond Javí Dara and Sághir Dasht, where he found the Kún-i-Gau Pass into Darwáz impracticable He therefore retraced his steps to Deh Lálá, near Mominábád, where he waited awhile, until he heard that the Walwalak Pass into Darwáz was open. He then crossed into the Dara Imám Valley, and having traversed that to its head he returned on his steps, and then crossed the Walwalak Pass into the valley of the Panjah. He now followed the course of the river Panjah upwards, over ground previously unexplored, to Kila Khum, where he struck the route of the Havildar. This route he followed to the junction of Wanj

MAP of the Routes followed by
Explorers: D.C.S. from Darjeeling to Shigatse during 1879.
G.S.S. in Nepal during 1884 & 1885.
G.M.S. from Shigatse to Khamba Jong during 1880.
also some routes of former Explorers
the rests of the routes of the Surveys by the Darjeeling Survey Party during 1879–85
Compiled by Captain H. J. HARMAN, R.E. June 1885
Scale 16 Miles = 1 Inch.
References
Railway
Roads
approximate position of Tracts
Scale 16 Miles = 1 Inch.
KATMANDU
Patan
BENGAL
DARJEELING
KALIMPONG
MOUPPFORE
TIBBET
DEBRUNGA
Photolithographed at the Office of the Topographical Branch, Bureau of India, Dehra Dún, October 1885

with the Panjah, and then crossed to the south bank of the river and ascended it up to Varv, opposite Kila Yaz Ghulám, where the Havildar had been turned back because of hostilities between the people of Darwáz and their neighbours in Roshán and Shignán. At Varv he too was turned back for similar reasons. He retraced his steps to the Dara Imám, and then followed the course of the Nayán river downwards to its junction with the Panjah, and on to Kisht. Here he crossed the Panjah river and then ascended the table-land of Shiva, and explored a route, hitherto wholly unknown, taking him across the central regions of Badakshán and into the upper basin of the Panjah river, which he struck a little above Kila Bar Panjah. He now proceeded down the river, passing near Kila Wámar, and eventually reaching Varv, the point from which he had been turned back on his journey up from Kila Khum. He thus secured an important link, which had hitherto been wanting to complete the course of the Panjah river. He then retraced his steps to Akhún, and proceeded *viâ* Kila Wámar up the Bartang or Murghabi Valley, which he ascended to the highest inhabited point. He found conclusively that this river rises in the Sarez Pámír, and is not—what it has hitherto been supposed to be—a continuation of the channel of the well known Aksú river, which rises in the regions to the east of the Great Pámír. He was unable to strike into the lower valley of the Aksú; but from such information as he was able to obtain, it appears that the river merges into the Sochan river, which joins the Shákh Dara river at Yamraj, the united streams passing into the Panjah river a little above Kila Bar Panjah.

193. Returning from the Sarez Pámír down to Kila Wámar, M— S— retraced his steps to Kila Bar Panjah, where he was laid up for five months by a severe attack of rheumatism. On recovery he proceeded to explore the Shákh Dara Valley, with the intention of crossing into Wakhán over the intermediate range of hills; but the passes were then blocked with sand, and impracticable. He was thus compelled to retrace his steps to Bar Panjah. He followed the course of the Panjah to Ishkásham, along the route already traversed by Captain Trotter's explorer, A— S—, and made a connection with his former traverse at Turbat, near that place. Returning to Baroghil, he took the opportunity of visiting the Gház Kol lake at the source of the Yárkhun or Mustauj river; having determined its position, he turned his steps towards the Darkoth Pass, and closed his work there

194. M— S— has not only added considerably to our knowledge of the geography of Badakhshán and the countries bordering on it, but he has furnished many additional details regarding the routes which had been previously traversed. His work combines with previous surveys to furnish a well nigh complete delineation of the great bend in the Panjah river in its downward course from Wakhán through the mountains out of which it emerges into the plains, to be known thenceforth as the river Oxus.

195. He has been presented with one of the two medals which were placed at the disposal of the Surveyer-General by the Venice International Geographical Congress for award to meritorious Native explorers.

2.—EXPLORATIONS ON THE FRONTIERS OF SIKKIM.

196. In 1879 Babu D. C. S., a learned man—attached to the Educational Department under the Government of Bengal—was about to proceed to Shigatze on business of his own. Being anxious to make the most of his opportunities for acquiring new geographical information, he applied for instruction at the Surveyor-General's Office in Calcutta, where he was put through a course of training by Pandit Nain Sing, the well-known Trans-Himalayan explorer. Starting from Jongri, in Sikkim, he crossed over the Kanchinjinga range to Yamga-tshal, in Nepal, on one of the upper affluents of the Tambur river; then, taking the route which sometimes skirts, sometimes crosses, the western spurs of the Kanchinjinga, he went to the monastery of Tashichoding, near the village of Giamsar (Dr. Hooker's Khambachen); crossed over the formidable Chatang Pass, on the border line between Nepal and Tibet, into a plateau at the head of the Zemu river of Sikkim; then crossed the easier pass of Chorten Nyima Kang into the Tibetan province of Chang; traversed that province—taking a route to the west of the well-known town of Khamba Jong—and eventually reached Shigatze. On returning to India, he retraced his footsteps until he arrived near Khamba Jong.

He then took the route which leads through that town to Sikkim over the Donkia Pass, on crossing which he passed out of the region of geographical reconnaissance into that of actual survey His journey has been fruitful of information: the observations of bearings and distances have been carefully taken and recorded, and are of much value for the requirements of mapping.

197. In 1880-81 G. S. S., a Hindoo of some account among his co-religionists, who had volunteered his services for exploration in Tibet, was deputed by Captain Harman from Sikkim to proceed towards the Dingri Maidan *viâ* the valley of the Tambar river in Nepal, a line of operation which would have taken him over much new ground. Instead, however, of ascending the Tambur Valley, he passed on to the parallel valley of the Arun, which he ascended to the so-called 'Popte' range, or, more strictly speaking, watershed, which here forms the boundary between Nepal and Tibet. Crossing the watershed, he advanced to the Tibetan village of Karta, beyond which he says he was not allowed to go. His journals are far from satisfactory, the observations being few and disconnected. Still, however, he has acquired some new information, chiefly of routes in Nepal, which is useful, as so little of Nepal is known to Europeans.

198. Captain Harman has constructed a map of the routes taken by Baboo D. C. S. in his travels from Darjeeling to Shigatze and back, and has prepared a detailed account of the journey. He has also made the most of the incomplete and unsatisfactory observations of G. S. S. that can be done in the way of mapping, and prepared an account of the travels of this explorer. Captain Harman has also prepared the map of routes followed by explorers, which faces the present page, and is based on a portion of sheet 9 of the Trans-Frontier series of maps prepared in the Trigonometrical Survey Office at Dehra Dún. He has given a memorandum explanatory of the construction of this map, and another memorandum on the most probable value to be adopted for the longitude of Shigatze, both of which will be found in the Appendix. He has taken great pains in the elucidation of information regarding the geography of the regions beyond the frontiers of Sikkim; and from the stations of the survey in Sikkim, he and his assistant, Mr. Robert, have taken observations which have fixed a number of peaks on the ranges beyond the frontier, and thus extended the area of accurate framework which is of such use in compiling maps from the comparatively rough and rude observations of geographical reconnaissance.

3.—EXPLORATIONS IN GREAT TIBET.

199. In 1877 arrangements were made to send one of the explorers of this department into the regions of Northern Tibet, which are crossed by the parallel of 40° of latitude. In those days the Russian Prejevalsky had not yet made his famous journey from Guldja to Lob Nur, and there was a great belt of territory between Eastern Turkestan and Mongolia which was almost absolutely unknown. A native of India, who had accompanied the celebrated Pandit Nain Singh in his travels, was specially trained by the Pandit to undertake this new exploration. He started from India in the summer of 1878 with two companions. For a long time no tidings were received of him; but about a year ago very distressing rumours reached Nain Singh, to the effect that he and one of his companions had been seized by the authorities at Lassa; that his companion, who was a Tibetan, had been put to death for having brought a foreigner into the country; and that he himself had had his legs broken, in order to put it out of his power to make further explorations. Happily this tale turned out to be a pure fabrication, concocted very probably by his second companion, who had meanwhile robbed and deserted him. In May last, tidings were received from the Vicar Apostolic of Tibet, who resides at Ta-tsien-lu, that the explorer had reached Ta-tsien-lu in safety last February, and that he was about to return to India by the direct route *viâ* Assam. He reached Calcutta very recently, bringing with him not only his journals, but his instruments, which he has managed to secrete and preserve in some wonderful manner, notwithstanding that on two occasions he was robbed of the greater portion of his property.

200. He has taken a number of astronomical observations, and kept up a more or less continuous record of bearings and distances along the line of

his traverse. Some time must elapse before his observations can be reduced and plotted; thus at present no very definite information can be given regarding the geographical results of this last and most important Trans-Himalayan exploration. The general direction of the lines of operation can, however, be indicated.

The explorer, after spending some time at Lassa purchasing merchandise for sale in the regions to which he was bound, and making arrangements to join a *kafila* of traders returning to Mongolia, eventually succeeded in making a good start. He accompanied the *kafila* as far as a place called Thingali, which may be some 150 miles to the west of lake Koko Nur. There, in December 1879, the *kafila* was attacked by a band of some hundred mounted men of the Chiamogolok tribe. They robbed the explorer of most of his property, but had the grace to leave him about Rs. 200 worth of merchandise wherewith to prosecute his enterprise, and they did not appropriate his surveying instruments. From Thingali he struck off to the north-west, and eventually reached a place called Saithang, where he had to wait for the formation of a *kafila* of travellers proceeding towards Lob Nur. There he was deserted by one of his companions, who robbed him of most of his little remaining property and his telescope. Though left nearly destitute he was resolved not to turn back, could he by any means avoid doing so. He and his remaining companion therefore took service with some Mongolians and tended their herds of horses for some months. Eventually they determined to move on with the limited funds at their disposal, and when these failed, to beg their way. They advanced to a place called Saitu, which may possibly be identical with Marco Polo's Sachiu. There they were detained seven months by Chinese Tartars, whom they were compelled to serve. Eventually a friendly Lama came to their assistance and rescued them, and in his service they returned to Saithang and proceeded south-eastwards to Barong Chaidam, some 100 miles to the west of lake Koko Nur, and then southwards 300 miles to the Thuden Gompa monastery. There they entered the service of a Chinese Tartar, whom they accompanied to Darchendo or Ta-tsien-lu, where they were kindly welcomed and helped by the Jesuit Fathers. They then commenced their return journey to India. Proceeding *viâ* Batang and Dzayul they reached Sama, a village on the eastern border of the country of the Mishmis. They endeavoured to make arrangements to cross the belt of Mishmi country between Sama and the British Frontier, but did not succeed in so doing; and being told that they would probably be murdered if they trusted themselves to such savages as the Mishmis, they turned northwards and took the circuitous route through Southern Tibet towards Lassa *viâ* Alanto and Giamda, as far as the latter place, from which they turned down south-westwards to Chetang, on the Sanpo river, avoiding Lassa. Thence they proceeded *viâ* Giangze Jong and Phari to Darjeeling, returning in safety to British territory after an absence of more than four years.

201. Sama, the village on the Mishmi border at which they turned away from the direct route to Assam, the explorer states to be situated on a river flowing into Assam, and to be the place at which two *padre sahibs* were murdered some thirty years ago. Thus it is identified with the Samé of the Revd. T. D. Mazure, Vicar Apostolic of Tibet, in a memorandum on the countries between Tibet, Yunan, and Burma, published in Volume xxx of the Journals of the Asiatic Society, in which he speaks of it as the place where the two priests, Messrs. Krick and Boury, were murdered. The Vicar was, however, under the impression that his Samé was situated in the valley of a river flowing into the Irrawady; but Colonel Yule, in his notes to the Vicar's paper, points out that we know from the reports of the British officers in Upper Assam that the two priests were murdered (about the month of August 1854) at a village called Simé in Wilcox's map, which is situated on the banks of the Brahmakund river—the eastern Brahmaputra—and he goes on to say that "this murder of two missionaries becomes thus, in fact, the basis of a geographical connection between British India and Tibet." This remark is even more apposite at the present time than it was originally; for the murder of the missionaries enables us to identify with certainty the nearest point to the British Frontier which was reached by the explorer on his attempt to return to India *viâ* Assam. Wilcox reconnoitred

the Brahmakund river up as far as the village of Samleh, and he obtained the positions of several of the villages higher up, from native information. Thus it appears that his Simé was about 18 miles beyond Samleh. For this portion of the river we as yet have no route survey; but the distance is so short that we may accept the position assigned to Simé in Wilcox's map without hesitation.

202. This being the case, the fact that the explorer was unable to proceed to India directly through the Mishmi country, but was compelled to make a considerable detour to the north, has been the means of our acquiring much additional geographical information, and more particularly of laying at rest the frequently-mooted question whether the great Sanpo river of Tibet flows into the Irrawady river or into the Brahmaputra. If the former, the explorer must have crossed it three times, first between Batang and Sama, secondly between Sama and Alanto, and finally at Chetang. He maintains that he only crossed it at Chetang, and that to the west of his route, between Sama and Alanto, there is a great range of hills, forming the water parting between the affluents of the Sanpo river and those of the well-known system of parallel Tibetan rivers which he crossed between Batang and Sama. He knows the Sanpo river well, and has crossed it frequently and in various places, and he is satisfied that none of the affluents of the system of parallel rivers which he crossed can possibly be the Sanpo.

203. A full account of his explorations will be got ready for publication, with maps in illustration, as soon as possible, probably within six months. Meanwhile, however, this statement of general outlines will suffice to show that the explorer has worked with great pluck and perseverance, never allowing himself to be turned back by misfortune and disaster, until he had succeeded in accomplishing a highly creditable amount of work, and meanwhile taking service with Mongolians, Lamas, and Chinese Tartars with a view to earn a livelihood for himself and his companion while carrying out the explorations.

TIDAL AND LEVELING OPERATIONS.

XXVIII.—THE TIDAL OPERATIONS.

204. The tidal observations and investigations have been duly continued, as formerly, in accordance with the programme prescribed by the Government of India for obtaining a systematic record of tidal phenomena on Indian coasts, which was published in section XI of the General Report on the operations of the Great Trigonometrical Survey for 1876-77. Major Baird, the officer by whom they were initiated, has been absent in Europe on furlough for the whole of the year under review, where, however, he has employed much of his leisure in promoting the investigation of the Indian tides. His place in charge of the operations has been held during the present year chiefly by Major Rogers, but partly by Major Hill, who, having to pass a military examination, was located at Poona, the head-quarters of the Tidal Party, and placed in charge of the operations, while Major Rogers took the field in charge of the Eastern Frontier Series Party.

Personnel.

Major J. Hill, R.E., Deputy Superintendent, 4th grade, in charge up to 15th April.
Major M. W. Rogers, R.E., Deputy Superintendent, 4th grade, in charge after 15th April.
Mr. W. G. Beverley, Assistant Superintendent, 1st grade.
Mr. G. Belcham, Surveyor, 4th grade.
„ E. J. Connor, Assistant „ 1st „
Sub-Surveyor Dhonda Venayeh.

205. The stations at which observations have been taken this year with the large self-registering tide-gauges of this Department are the following:—

Aden.	Negapatam.	Dublat (Saugor Island).
Kurrachee.	Madras.	Rangoon.
Bombay.	Vizagapetam.	Moulmein.
Karwar.	False Point.	Amherst.
Beypore.	Kidderpore.	Port Blair.
Paumben.	Diamond Harbour.	

The tidal station which had been established at Elephant Point, below Rangoon, has been dismantled and moved to another site higher up the river, together with the Telegraph Office and other public buildings, as the original site was being carried away by the river. The tidal station at Bhaunagar,

erected at the cost of His Highness the Thakur of Bhaunagar, has met with an accident, which has prevented the setting up of a tide-gauge. Thus no observations have been taken at either of these stations during the present year.

Account of the Registrations, &c., at each Station.

206. At Aden the tide-gauge has been working very well, with only two stoppages, both unimportant. The observatory was inspected by Mr. Belcham in December 1881, when all the instruments and driving clocks were taken to pieces and cleaned. The self-registering aneroid barometer and anemometer have unfortunately been unserviceable for the greater part of the year, and are being replaced by new instruments. Captain Thyne, the Port Officer, has rendered much assistance in supervising the work of the clerk in charge.

207. At Kurrachee the new large-scale tide-gauge, which was erected in the place of the small-scale gauge set up some years ago by Mr. Parker—in connection with the harbour improvement works—has been working very satisfactorily, the stoppages having been few and unimportant. The aneroid barometer has worked well. The registrations of the direction and velocity of the wind have been taken from an anemometer which is employed in connection with the harbour works.

208. At Bombay the registrations of the tide-gauge have been continuous, and in every way satisfactory; as also have been those of the self-recording meteorological instruments.

209. At Karwar the tide-gauge has worked well, with few and unimportant interruptions; the catgut string carrying the back-lash weight was frequently bitten through by rats, and eventually wire had to be substituted for it. The aneroid barometer has been working satisfactorily, but not the anemometer, which appears to have become worn out, and must be replaced by a new instrument.

210. At Beypore the tidal registrations have been continuous and satisfactory. The meteorological records were frequently interrupted; a fly-catcher was found to have made its nest in the case of the clock of the aneroid barometer; and the anemometer was injured by violent gales during the monsoon of 1881. The observatory was inspected by Mr. Belcham in February 1882, when the instruments were put into working order, and since then they have registered satisfactorily.

211. At Paumben some interruptions in the tidal registrations were caused by the pipe which connects the well of the gauge with the sea becoming corroded A new pipe was substituted and general repairs were effected in February 1882, and since then all has gone on satisfactorily. The aneroid registrations have been fairly continuous. No anemometer registrations have been made, as no instrument was available for the purpose.

212. At Negapatam the site primarily selected had been objected to on the ground that an observatory erected there would interfere with the traffic; a new site was therefore chosen on the western side of the back-water, about 100 yards south of the pier. A substantial structure was erected for the observatory; the instruments were set up, but with some delay, owing to a mistake on the part of the packers in England, who had sent out the barrel of one tide-gauge and the clock of another: thus the two had to be fitted together, which was done at the contiguous railway workshops. The tidal registrations were fairly started by the 1st November 1881; but some time elapsed before the clerk in charge succeeded in mastering the details of the manipulation, and meanwhile there were several breaks of continuity in the record. The anemometer has been working well, but not so the aneroid, the clock of which appears to have been badly constructed originally, and subsequently the registering barrel was let fall by the clerk and so much injured that for some time the instrument was unserviceable.

213. At Madras the tidal registrations have been carried on satisfactorily throughout the year. In February, when the periodical inspection was made, the pipes connecting the well of the gauge with the sea were thoroughly cleaned, and this necessitated a stoppage of the registration for 17 days. The cyclone of the 12th November, which destroyed a large portion of the walls for the protection of the new harbour, did no injury to the gauge; but of course the transfer of the gauge from the present wooden pier to a preferable site on

the new masonry pier has been postponed indefinitely. Captain Taylor, the Master Attendant, has rendered much assistance both here and at other ports on the Madras coast. Barometric and anemometric registrations are not made at the tidal station, as all necessary information regarding these meteorological elements should be obtainable from the Government Astronomer at Madras, being regularly recorded at his observatory.

214. At Vizagapatam the tidal registrations have been satisfactory on the whole, the breaks of continuity being few and unimportant. The anemometer has worked well throughout, and the aneroid for about half the year. The timber piles supporting the observatory have been eaten away to an extent which is reported to have imperilled the safety of the observatory; but steps have been taken to strengthen them sufficiently to last for another year, after which further observations will be unnecessary.

215. At False Point the tidal registrations have been going on more satisfactorily than last year, and there have been no stoppages of more than a few hours. In May 1881 it was detected that a general settlement of the staging on which the observatory was erected had been going on for some time, the bed plate of the gauge having sunk about seven inches since the instrument was first set up; the levels were again tested in December 1881 and May 1882, when further settlements of $1\frac{1}{2}''$ and $1''$ were found to have taken place, showing continuously progressive settlement at the rate of about two-tenths of an inch monthly. This has necessitated the application of corresponding corrections to the tidal registrations in order to reduce them to a fixed datum.

216. At Kidderpore the tidal registrations have been fairly continuous, but with occasional short breaks; these were caused by the stoppage of the pendulum of the driving clock, which is attributed to shocks communicated by boats bumping against the piles on which the observatory is supported, and to vibrations caused by the action of the winds and tides. The barometric and anemometric registrations show several breaks, but these may be filled in with the aid of the records of the meteorological observatory at Alipore.

217. At Diamond Harbour so many breaks of continuity in the tidal registrations were caused by the stoppage of the pendulum of the clock, for the same reasons as at Kidderpore, that an attempt was made to substitute for the usual clock one of the chronometer escapement clocks which had been specially provided for employment on staging unsuited for pendulum clocks. The chronometer escapements were found, however, to be too delicate for the purpose, the hair springs being liable to break on very slight provocation: thus after a time the pendulum clocks had to be reverted to. The aneroid registrations were continuous throughout the year, and those of the anemometer for eleven months.

218. At Dublat the registrations of the tide-gauge were interrupted for 19 days because the bridge connecting the observatory with the shore was carried away in a storm. The staging is not sufficiently substantial and requires to be much strengthened. Here, as at Diamond Harbour, an escapement clock is necessary in place of the pendulum clock. The anemometer registrations have been most satisfactory throughout the year, but the aneroid barometer was frequently out of order.

219. At Rangoon the observations have been carried on satisfactorily, but there have been numerous short stoppages of the clocks of all the instruments, due for the most part to the traffic on the wharf on which the observatory is set up. The immediate charge of the operations has been transferred from the Executive Engineer, Mr. King—who has given much valuable assistance—to an officer of the Port Trust.

220. At Elephant Point the site of the observatory was so nearly cut away by the river that it became necessary to dismantle the instruments and remove them for safety to the Telegraph Offices. The observatory, whilst being removed on a raft, was washed away and lost. A new site was selected by Major Rogers in March 1882, at the mouth of the Pee-li-ka Creek, about two miles from the Point, which, though not quite as open to the sea as the old one, has the advantage of being safe from the erosion of the river; the Port Trust is about to erect an observatory there. Observations had been carried on at the first site for nearly a year, and though their value is impaired by numerous breaks, they have sufficed for the construction of preliminary tide tables.

221. At Moulmein the tidal registrations are reported to have progressed fairly well on the whole; but there have been frequent short stoppages of the pendulum clock, caused by vibrations of the pier on which the observatory is set up. The aneroid and anemometer have worked satisfactorily. A robbery took place here in June 1881, the only one that has occurred anywhere since the commencement of the tidal operations; the thieves took away such small articles as they could lay their hands on, and five of the tidal diagrams, in pure mischief, as the diagrams could not be of any use to them. Fortunately it is the custom every day to transcribe the hourly readings of the diagrams and post them to the office at Poona, in case of mishap to the diagrams: thus the theft was immaterial.

222. At Amherst there has been some erroneous tidal registration, because the pipes connecting the well of the gauge with the sea had become partially clogged with mud, a large amount of which is here held in suspension in the water. In such situations frequent flushing of the pipes is necessary; and when the clerk in charge neglects to do this, so much retardation takes place in the flow of water into and out of the well that the diagrams become inaccurate, and therefore useless. A sufficiency of correct registration has, however, been secured for the construction of tide tables for the coming year. The aneroid and anemometer registrations have been uniformly satisfactory.

223. At Port Blair the tidal registrations continue to be very satisfactory. This is due in great measure to the immediate supervision exercised by Mr. Humfrey, the Port Officer, who takes much interest in the operations. There have been two changes in the clerks in charge during the year: the present clerk is a convict, supplied by the Chief Commissioner, Major Protheroe. The aneroid registrations have been very satisfactory throughout the year. The anemometer was out of order, and had to be sent away for repair.

224. From the preceding description of the performances of the three self-registering instruments at each of the tidal stations, it will be obvious that a few spare clocks with spring escapements are required to be substituted for the pendulum clocks of the tide-gauges at observatories on piers and stagings which are subject to jars and concussions of sufficient force to stop the performance of a pendulum; also that a few spare aneroids and anemometers are needed to replace any instruments which are out of order and under repair, in order to preserve the continuity of the registrations. Application has therefore been made to the Director-General of Stores at the India Office to take early steps to supply four spare clocks with lever escapements, and as many self-registering aneroid barometers and anemometers, for future use.

225. Reference should be made to paragraphs 186 to 190 of last year's report for information regarding the scales of the tidal-curve diagrams—which are adjusted to vary with the amplitudes of the tides between extreme high and low water at different stations—the instrumental adjustments, the references to a fixed datum, the periodical inspections, the duties of the clerks in charge, the despatch of the diagrams to the central office at Poona, the preparation of numerical tables from the curves of the diagrams, and finally the evaluation of the tidal constants. These constants furnish the requisite data for the determination of any past or future tide, either by direct calculation, or with the aid of a tide-predicting machine, such as the one which has recently been constructed for the India Office, and is being employed by Mr. Roberts in the preparation of the tide tables for Indian ports, which are published under the orders of the Secretary of State for India.

226. During the present year large discrepancies were for the first time met with between the tidal predictions and the actual facts of the tides. This arose from the circumstance that it was for the present year that predictions had first been made for stations situated on the banks of great rivers, as the Hooghly and the Irrawaddy, in which the tides are influenced not only by the attractions of the sun and the moon, but by the amount of water brought down by the river from its sources, which varies at different seasons of the year. There are three tidal stations on the Hooghly—Kidderpore, Diamond Harbour, and Dublat; two on the Irrawaddy—Rangoon and Elephant Point; and one on the Salween river—Moulmein. Tide tables were computed for these riverain stations as if they had been purely oceanic stations, and these tables

were found to be erroneous to the extent of occasionally an hour or more in the times, and a foot or more in the heights, of high and low water. Attention was first drawn to the subject on comparing Mr. Roberts' tables for Kidderpore and the other stations on the Hooghly with the tide tables published by the Calcutta Port Commissioners. Mr. Roberts' tables were based on five years' tidal observations taken in connection with the operations of the Department of Public Works, before Major Baird's tidal stations were established; the observations had however been reduced by the modern method of harmonic analysis. The Port tables were based on tidal observations taken in connection with the surveys of the river-bed and channels which have been made from time to time by the Port authorities, and they were reduced by the methods usually followed by the surveyors to the Admiralty. On comparing both sets of tables with the subsequently acquired results of actual observation, it was found that Mr. Roberts' predictions of the times of high and low water were almost invariably too early, while the Port table predictions were generally too late, the errors of the former being greatest; the errors in the predictions of height were pretty equally balanced between excess and defect, and were in no case very material. The mean values of the two sets of tables are much more accurate than the values in either set taken singly.

These facts have shown the necessity for supplementing the mathematical formulæ for the harmonic analysis of purely luni-solar tides by formulæ to take cognizance of riverain influences. The subject is a very abstruse and difficult one, but it has been brought to the notice of some of the leading mathematicians in England, and there is much reason to expect that it will soon be satisfactorily disposed of. It is also expected that additions may be made to the India Office tide-predicting machine which will enable the machine to fulfil its functions as satisfactorily for stations situated on the banks of tidal rivers as it has done hitherto for stations situated on sea coasts. Meanwhile Mr. Roberts is adopting a provisional method of predicting tides for riverain ports, which is described below in an extract from his tide tables for Diamond Harbour, in the River Hooghly, for 1883.*

227. In addition to their practical value for the requirements of navigation, the Indian tidal observations are furnishing information which has already been found to be of much scientific value. Thus they have recently thrown light on the question of the degree of the rigidity of the earth, which was mooted about fifteen years ago by Sir William Thomson, who appealed to the universal existence of oceanic tides of considerable height as a proof that the earth, as a whole, possesses a high degree of rigidity, and maintained that the previously received geological hypothesis of a fluid interior was untenable. At the recent meeting of the British Association for the Advancement of Science at Southampton, Mr. G. H. Darwin brought forward a "numerical estimate of the rigidity of the earth," which gives evidence of a tidal yielding of the earth's mass, and further indicates that the effective rigidity of the whole earth is about equal to that of steel. But it is only recently that there has been a

* From a comparison made between the observations and the predictions for 1882, it appears that the number of short-period terms combined by the India Office tide-predicting machine is not nearly sufficient to reproduce the tide-curves for this place, nor Indian riverain ports generally, more especially for the phases of low-water. As it will take time to evaluate by the method of harmonic analysis the proper number of terms requisite to reproduce the tide-curves with the desired accuracy, recourse has been had to the following method of treatment, which, judging from an extended comparison of some months of the year 1882, made between the predictions and actual observations for Kidderpore, promises to yield predictions differing from the facts within narrow limits.

The observed times and heights of high and low-water were tabulated in the ordinary manner to produce the semimonstrual curves for time and height of high and low-water depending on the time of the moon's transit in apparent time, referred, however, to the transit at Greenwich about 40 anterior to the time of observation. The predictions were then obtained directly from the quantities thus found, and were corrected for lunar and solar parallax and declination by the tables contained in Sir John Lubbock's elementary treatise on the tides, which are used in the Nautical Almanac and Admiralty Offices for their tidal predictions. For the corrections to the heights of high and low-water the proportions between the London values of spring and neap tides compared with those of Diamond Harbour have been used. This method of treatment takes thus far into account semidiurnal tides only. In order to correct the predictions for the diurnal tides, the following plan has been adopted. The predictions for time of high and low-water for Dublat have been computed similarly to the above (the semimenstrual curves having been obtained from the actual predictions for 1883), and the differences taken between the times thus obtained and the times as given by the machine-curves. These differences represent fairly the effects of the diurnal tides. A proportionate part of these differences has been used for each high and low-water, and applied to the Diamond Harbour predictions of purely semidiurnal tides. In addition to these corrections, another (which may be termed a seasonal correction) has been applied for the freshets in the river, the general effect of which appears to be to accelerate the times to a considerable extent.

The predictions for the heights have been similarly corrected for the diurnal tides, and the solar annual and semiannual tides, excepting in this case the quantities, have been obtained directly by means of the India Office tide-predicting machine. The values of the diurnal and long-period tides used were those based on the evaluated results given in the tide tables for 1882

sufficient accumulation of tidal observations, properly reduced by harmonic analysis, to test Sir William Thomson's theory; and Mr. Darwin points out that the great advances in knowledge that have now been made are principally due to the adoption of systematic tidal observation at a great number of stations by the Indian Government.

228. Here it may be interesting to mention that the first systematic tidal observations which were made by this survey for reduction by the modern method of harmonic analysis were undertaken with the primary object of furnishing evidence regarding changes which were supposed to be taking place in the relations of the levels of the land and the sea; they were made by Major Baird, at three stations in the Gulf of Cutch, during the years 1873—75, with the intention that similar observations should be taken several years afterwards, when a sufficient interval had elapsed to allow time for a change of level of sufficient magnitude to be determined with certainty, from the first and last observations of the levels to take place. Whether the faith that a future generation would carry out an idea originating in the present generation which was then shown will ever be realised, remains to be seen. It so happens, however, that the recent tidal observations of this survey at another point are comparable with observations taken at the same place upwards of sixty years ago. In 1821 Colonel De Haviland of the Madras Engineers observed the mean-sea level at Madras, and by his determination the mean-sea was about one foot higher then, relatively to a fixed point on the shore, than it appears to be now by our recent determination of the relation between the present mean-sea and the same point—a stone bench-mark built into the wall of Fort St. George. The difference between the two results has hitherto been supposed to be due, possibly, to the circumstance that Colonel De Haviland's operations were restricted to observations of high and low water, and to a period of about 4½ months only; the observations have, however, been recently analysed by Major Rogers, who has found that they agree well with those of the present self-registering gauge in the times of high water relatively to the full and change of moon, and also in the times of spring tides; and further that the mean level of the sea during the months corresponding to those in which Colonel De Haviland's observations were made differs by less than half an inch from the mean value for the whole year, and is therefore a good value. Thus assuming no mistake to have been made in connecting the tidal observations with the bench-mark in Fort St. George—and such a mistake is very improbable—it may be considered established that the mean-sea level at Madras is about one foot lower, relatively to the land, now than it was sixty years ago.*

XXIX.—THE EARTHQUAKE OF THE 31ST DECEMBER 1881.

229. On the morning of the 31st December 1881 an earthquake occurred in the Bay of Bengal, which operated with considerable violence in the neighbourhood of the Andaman and Nicobar Islands, and with more or less violence along the entire length of the west coast of the Bay, from Ceylon to Calcutta, and was also felt, though comparatively slightly, at various points on the east coast. In addition to the ordinary shocks produced by the waves of force acting through the ground, the surface of the ocean was greatly disturbed, and waves were formed which continued to roll against the coast lines for several hours after the cessation of the earth-waves, which lasted for only a few seconds. The clerk in charge of the tidal observatory at Port Blair reported a great disturbance of the surface of the sea to have taken place there, which had violently agitated the pencil of the self-registering tide gauge, causing it to oscillate in the course of a few minutes through spaces nearly equal to the entire normal semi-diurnal oscillation, and after a time to tear the paper of the diagram. This had alarmed him so much that he stopped the clock and did not restart it for some hours, when there was less agitation of the sea-surface. He then found by the diagram that the earthquake waves were still

* Major Rogers reports:—"Mr. Belcham inspected the Indian Tidal Stations and worked in all respects satisfactorily.

"Mr. Connor had charge of the Computing Branch, and to his zeal and hard work the very successful outturn of computations is greatly due."

existing, and were following one another with great regularity; and they continued to do so for about twenty-five hours after the first shock of the earthquake was felt, when they died away. The diagrams at all the other tidal stations, for the same day, were then examined, and evidence of a succession of ocean-waves caused by the great earth-wave was unmistakeable at all the stations on the west coast of the Bay and at Dublat station—at the south end of Saugor Island—as well as at Port Blair. There was evidence of slight disturbance at Diamond Harbour, 38 miles up the Hooghly beyond Saugor Island; but there appeared to have been no disturbance whatever either of river-surface at Rangoon and Moulmein, or of ocean-surface at Amherst, and these are the only points on or near the east coast of the Bay at which tidal registrations were being taken.

230. Diagrams of the disturbed tidal curves, reduced from the original records, are here given to indicate what actually took place at each spot and at the same moment of time. For the latter purpose, all the hour lines of the diagrams have reference to local mean time at Port Blair. The curves from midnight of the 30th December up to the times when the sea-waves began to reach each station—which fall between 8 A.M. at Port Blair and 1 P.M. at Dublat, and possibly was as late as 3 P.M. at Diamond Harbour—are normal in every instance; and thus by comparing them with the curves for the remainder of the twenty-four hours, the influence of the earthquake in disturbing the normal tides is readily seen. For Port Blair and Negapatam the normal curves are drawn below the actual curves. At the former place the diagram was torn by the pencil, and the record is not continuous; at Negapatam the curve from midnight up to the commencement of the sea-waves is vibratory, and not firm, as at all the other stations; but there the curves are normally vibratory, probably because the piping, connecting the well of the gauge with the sea, ends in shallow water and has not been carried out far enough into the sea. The longitudes of the several tidal stations west of Port Blair, in time, are given in the margin.

	H.	M.
Diamond Harbour	0	18
Dublat	0	20
False Point	0	24
Vizagapatam	0	38
Madras	0	50
Negapatam	0	52
Paumben	0	54

231. Both the officers in charge of the tidal operations, first Major Hill and afterwards Major Rogers, have taken much pains to ascertain all the facts of the primary 'Great earth-wave' and the subsequent 'Sea-waves.' It so happened that at the time of the occurrence of the earth-wave Major Rogers was measuring angles with one of the great theodolites of this Survey at a station on the Island of Kisseraing, below Tenasserim, on the east coast of the Bay, as a part of the operations which are described in paragraph 34 of this report. He writes that he "saw the earthquake before feeling it," as he was at the moment observing a signal—distant some 15 miles—which appeared to rise and fall in the field of the telescope. On looking at the levels of his instrument, he found that they were violently agitated. He immediately recorded the time at which the phenomenon occurred. Subsequently he ascertained that the earthquake had been felt, at almost the same moment, at Madras and False Point, on the opposite coast. Thus then Major Rogers, assuming the great earth-wave to have travelled with equal velocity in all directions from the origin or centre of impulse, considers that the origin must have been situated at some point in the Bay nearly equi-distant from Madras, False Point, and Kisseraing,—not in the centre of the triangle joining the three places, but more to the south, towards the line joining Port Blair and Negapatam, which was probably the line of greatest disturbance, as at those places the sea-waves were greatest.

It is remarkable that there should be no indication of any sea-wave at either of the tidal stations at Rangoon, Elephant Point, Moulmein or Amherst. This may be due to the circumstance that the belt of islands and shoals which extends from Cape Negrais down to the Island of Sumatra forms a barrier to waves issuing from an origin near the centre of the Bay; the sea-waves were propelled with great violence against these islands on all sides and over the surrounding shallows, but they seem to have died away very rapidly in the deep sea beyond. Moreover, the great earth-wave must have operated with far greater force towards the west than towards the east of the centre of impulse; for violent shocks were felt all along the west coast of the Bay, and to a considerable distance inland, whereas on the east coast the shocks were very slight and barely perceptible.

To accompany Surveyor General's Report for 1881-82.

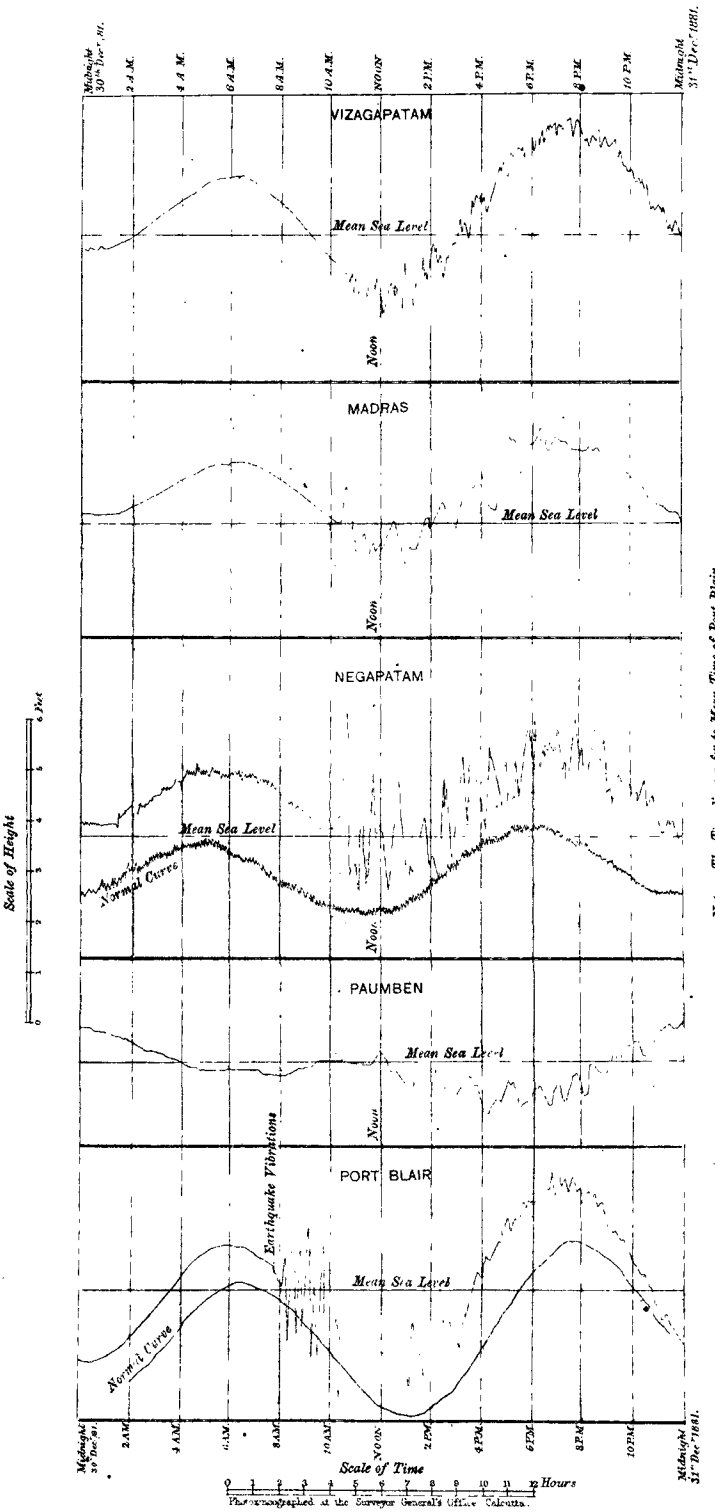
CHART OF BAY OF BENGAL

TO ILLUSTRATE REPORT ON TIDAL WAVES PRODUCED BY EARTH-QUAKE OF 31st DECEMBER 1881

Published under the Superintendence of Lieut. General J. T. Walker, C.B., R.E., F.R.S. Surveyor General of India.

TIDAL CURVES.

To illustrate the effects of the Earthquake of the 31st December 1881.

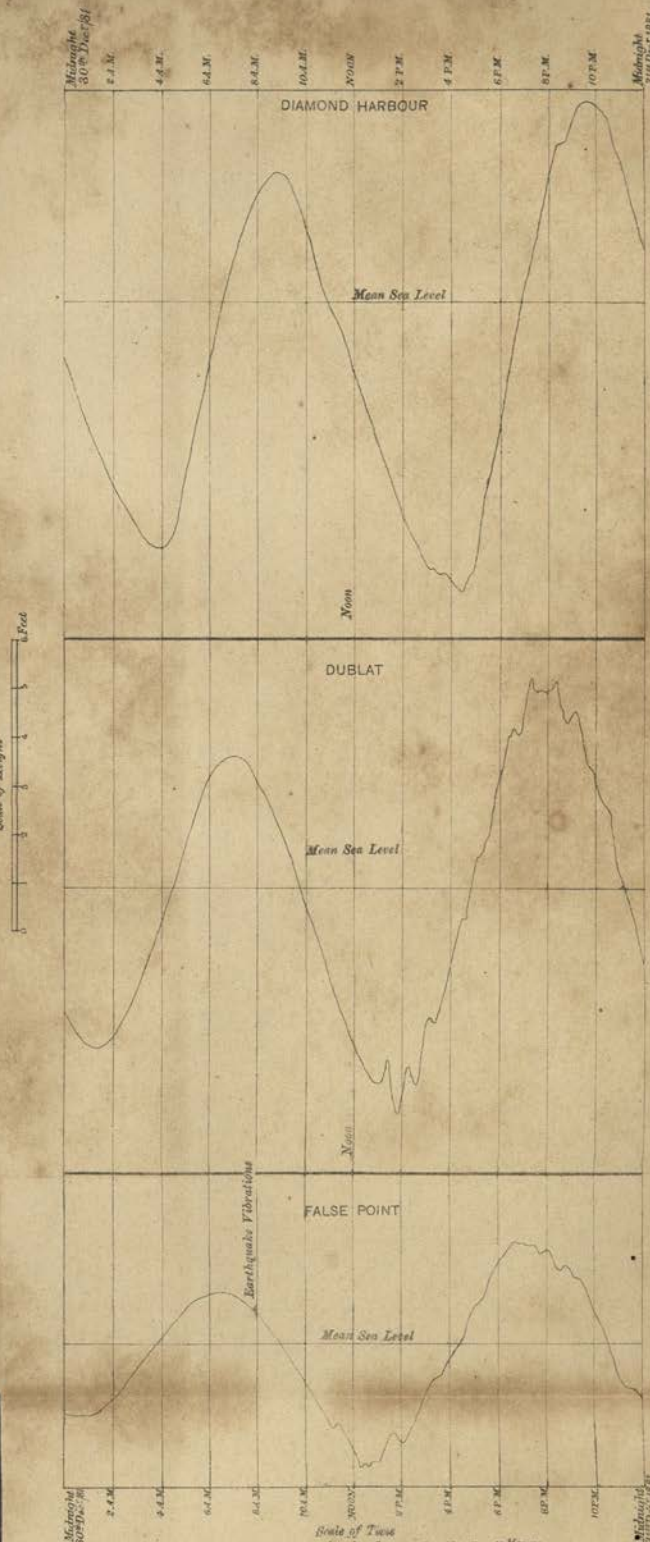


Note.—The Time lines refer to Mean Time of Port Blair.

Photozincographed at the Surveyor General's Office, Calcutta.

TIDAL CURVES.

To illustrate the effects of the Earthquake of the 31*st December* 1881.



Photolithographed at the Surveyor General's Office, Calcutta.

232. The accompanying Chart of the Bay of Bengal shows the positions of all the tidal stations on both coasts, the trigonometrical station at Kisseraing, and Major Rogers' assumed centre of impulse. It also gives the values of all the soundings in the Bay which are believed to have yet been taken. Major Rogers' report is given *in extenso* in the appendix, and will be found to contain much additional matter of interest, including estimates of the respective velocities of the earth-wave and the primary sea-waves. It is believed that so full an account and such precise details of the phenomena of an earthquake have rarely been acquired hitherto. That they have been obtained in the present instance is mainly due to the existence of the many tidal stations which have been established on Indian coasts.

XXX.—THE SPIRIT-LEVELING OPERATIONS.

1.—THE OPERATIONS EXECUTED IN CONNECTION WITH THE TIDAL OBSERVATIONS.

233. These operations have for their object the connection of the several tidal stations by lines of spirit levels running along the coast lines and across the continent from sea to sea; also the connection of the principal stations of the great triangulation which fall in the neighbourhood of the lines of levels, with a view to the rectification of the differences of height which have already been determined by the less accurate trigonometrical method; and also, collaterally with these operations, the connection of the bench-marks of the Irrigation, Railway, and other branches of the Department of Public Works, with a view to their general combination and reduction to a common datum.

234. During the present year the main line of spirit-leveling was entrusted to Mr. Rendell. His first duty was to revise the western ghât section of the line of levels from Bombay to Madras, with a view to ascertaining whether any accidental error had been committed in leveling up the steep ascent of the ghâts that would account for the discrepancy of three feet which had been met with at Madras on comparing the value of the mean sea determined from the local tidal observations with the value given by the spirit-leveling from Bombay. This has already been fully set forth in section XXVIII of the annual report for last year. The revision giving practically identical results with the first operations, Mr. Rendell proceeded to Calcutta and commenced a main line of levels to connect the tidal stations at Kidderpore, Diamond Harbour, and Dublat in the river Hooghly with the nearest tidal station on the sea coast, viz. the one at False Point on the Cuttack coast line.

Personnel.

Mr. Rendell.
Sub-Surveyor Narsing Dass and two recorders.

235. Operations were commenced at False Point tidal station, whence the line of levels was taken along the coast to the lighthouse, and then across a very difficult network of creeks at the mouth of the Mahanadi river to the banks of Kendrapara canal. There *terra firma* was reached after wading for a distance of about 18 miles through an extensive jungly swamp, which is wholly covered with water at spring tides, and is never entirely free from it. The stands of the instruments had frequently to be set up in water two to three feet deep; and as the soil below was loose and slushy, so that any movement on the part of the observer disturbed the level of the telescope, Mr. Rendell had to summon up his coadjutor, Narsing Dass, from a station in rear to read the level at the moment that he was reading the staves with the telescope, and then to return and perform the same duty for his coadjutor; thus the independent measurement of the double line was maintained throughout in accordance with the long-established procedure for these operations, but with very much more of difficulty and delay. After reaching the banks of the Kendrapara canal the operations were carried on, as usual, across country to Jhajpur, and thence along the Grand Trunk Road to Balasore. From Balasore a branch line was carried to the coast to connect the old tidal station at Balaramgarhi, while the main line was taken *viâ* Contai to the Kakrahati ferry, across the Hooghly river, on the direct road to Calcutta. Various rivers and creeks, ranging from one quarter to three quarters of a mile in breadth, had to be crossed before Kakrahati was reached; but in all instances the crossing was accomplished by direct spirit-leveling, though occasionally staves with broader graduations

than those in ordinary use had to be employed, the distances being so great. To cross the Hooghly river in this manner was, however, found impracticable, the river being considerably over a mile in breadth at its narrowest part. Mr. Rendell therefore set up temporary tide gauges on both banks, at a part where the main channel and the banks were parallel to each other. He and his coadjutor took simultaneous readings of both gauges at the times of high water, rising tide, and falling tide. Upwards of three hundred observations, extending over four days, were taken. A difference of level of nearly two inches was found between rising and falling tides; but the mean of both differed by only 65 of an inch from the level at the top of the tide when the surface of the river was neither rising nor falling. The general mean may be accepted as within half an inch of the truth, and is probably much more exact than any result which might have been obtained by measuring the vertical angles across the river, or by any other process.

236. After crossing the Hooghly river the line of levels was taken down to Diamond Harbour and connected with the tidal station there. It had still to be carried to the Dublat tidal station at the south end of Saugor Island; but the field season was now well advanced, and by the time that the line was brought down to the Baratola river, on the crossing to Saugor Island, strong winds had set in, which could not be faced by native boats; and as the survey party was dependent on these boats for the carriage of water and provisions, and usually resided on board of them, it was necessary to cease working downwards, and to proceed to Dublat by way of the inland creeks and back-waters. Thence the leveling was taken upwards, *viâ* the Saugor Light House, to the Baratola river, where a junction was effected with the down line. The party was now thoroughly exhausted, having undergone great hardships and much exposure. Field operations were therefore suspended. The out-turn of work is very creditable to Mr Rendell; for the length of main line leveled is as much as 380 miles, of which more than half fell on marshes, swamps, and paddy-fields, which had to be operated over very carefully and slowly. The several crossings of rivers and tidal creeks were also very troublesome, and caused much delay, and the exposure generally was excessive.

237. The programme for the next field season includes the completion of the line from False Point by the connection of the tidal station at Diamond Harbour with that at Kidderpore, and a further connection with the main line which was carried in the years 1858–65 from Kurrachee through Sind, the Punjab, the North-Western Provinces, and Western Bengal to Calcutta. Lines of levels will also be carried along both banks of the river Hooghly to furnish data for the elaborate survey of that river and its banks, which is now being carried on conjointly by this Department and the Commissioners of the Port of Calcutta, as described in section XIII of the present report.

238. Subsidiary lines of levels were executed by a detachment from the tidal and leveling party in the districts of Nasik and Ahmednagar with a view to the correction of the heights of the principal stations at the southern ends of the Khanpisura and Singi series of principal triangles. These heights were mostly determined 30 to 50 years ago by the trigonometrical method, and they have been found to be less accurate than is desirable, the observations having in many instances been taken at other times than that of minimum terrestrial refraction, the laws of which were scarcely known then. Thus a revision of these heights was very necessary. It was undertaken by Mr. Beverley, who made a combination of the trigonometrical and spirit-leveling methods of operation, measuring the vertical angles at stations of the auxiliary line of levels to the surrounding trigonometrical stations, which were mostly situated on high hills inaccessible to the spirit-leveler. Mr. W. G. Beverley was prevented from continuing in the field for a full season by ill health, to which he afterwards succumbed, dying at Poona in September. Mr. Beverley entered the Survey Department in the junior or subordinate branch in 1854. He served in that branch for about 17 years, during which he did such good service in the Himalayan surveys, chiefly under the late Lieutenant-Colonel T. G. Montgomerie, R.E., that he was promoted in 1871 to the senior branch.*

* Major Rogers reports:—"Mr. Rendell carried his levels through exceptionally trying and difficult country and showed great energy and intelligence in the prosecution of his work.
"Narsing Dass worked excellently.
"The computers in general gave satisfaction."

2.—THE OPERATIONS IN CONNECTION WITH THE REVENUE SURVEYS.

239. The small party of levelers which has been employed for two previous seasons in the Hanthawaddy district of British Burma has again been organized. At the commencement of the season, the party first measured a line of 20 miles to close a circuit which had been left unfinished the previous year, and thus completed the several series of levels which had been laid out for the Hanthawaddy district.

240. The party then became free to take up new work of a special character, which had been planned in accordance with the wish of the Chief Commissioner that leveling should be done in connection with the survey operations in the Bassein district, as well as in Hanthawaddy. The character of the country where the Bassein cadastral party has been operating, situated as it is in the heart of the Irrawaddy delta, a tract largely intersected with tidal creeks, rendered it unnecessary that the ordinary plan of placing lines of levels at fixed intervals should be adopted; and it was desirable that special lines should be selected, such as would be most useful for practical purposes. This selection could best be made by an officer of the Public Works Department, who would be likely to make practical use of the level data. Accordingly, Mr. R. Gordon, Executive Engineer of the Henzadah Division, an officer whose duties had specially led him to give much attention to the physical character of the valley of the Irrawaddy, was consulted on the subject, and asked to say where he would recommend the lines of levels to be placed. Mr. Gordon's plan is to have lines of levels carried along two main branches of the Irrawaddy—one line from Pagoda Point, at the mouth of the Bassein river, the other from a little below Maoobin, on the China Bakeer river joining a little above Henzadah, and thence a single line northwards following the river up to the frontier. From Henzadah, another line will branch off eastwards to the Prome Railway, following which southwards it will terminate at Rangoon. This scheme was forwarded for the consideration of Mr. Furnival, Chief Engineer at Rangoon, who added traverse sections across the valley in the neighbourhood of Henzadah in addition to Mr. Gordon's river lines.

241. A commencement has been made of this plan of leveling by taking a line from a bench-mark of the Hanthawaddy levels to the eastern branch of the Irrawaddy near Maoobin, and thence following the river up to Henzadah. From this point, Major McCullagh, who has superintended the operations, had intended to have had a line taken eastwards to the railway, and thus to have completed a circuit through the railway series of levels and the Hanthawaddy levels, but the setting in of the rains prevented the programme from being carried out. The line of levels measured is 128 miles in length and double throughout. The number of bench-marks is 129, some of them being specially fixed marks, and some of them existing permanent objects. In carrying out the river line, the levelers had many difficulties to overcome, with many miles of high grass and jungle to cut through, and numerous streams, large and small, to cross. The levelers and the establishment suffered much from fever.

GEODETIC.

XXXI.—ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

242. The electro-telegraphic operations for the determination of the differential longitudes of certain stations of the principal triangulation were resumed last year, after remaining in abeyance since the season of 1876-77, as already intimated in the last report. They have been continued during the current year by Major George Strahan and Major Heaviside, Major Strahan taking the place of Lieutenant-Colonel Campbell, who went on leave at the commencement of the field season, and returning at its end relieved Major Heaviside and thus enabled him to take leave during the recess.

Personnel.

(No. 1 Astronomical Party.)

Major W. J. Heaviside, R.E. (field season), Deputy Superintendent, 3rd grade.
Lieutenant-Colonel W. M. Campbell, R.E., (recess) Deputy Superintendent, 2nd grade.
Mr. D. Atkinson, (recess) Surveyor, 2nd grade.
Sub-Surveyor Dhondo Balwant Joshi.

(No. 2 Astronomical Party.)

Major George Strahan, R.E., Deputy Superintendent, 2nd grade.
Mr. J. Bond, Assistant Surveyor, 1st grade.
Sub-Surveyor Baboo Harsahai.

243. During the present year seven arcs have been measured, as follows:—

Fyzabad–Agra.	Hazaribagh–Calcutta.
Fyzabad–Jubbulpur.	Hazaribagh–Julpaigori.
Fyzabad–Hazaribagh.	Julpaigori–Calcutta.
Jubbulpur–Hazaribagh.	

An eighth arc, Fyzabad–Julpaigori, had been included in the programme for the field season; but before it could be commenced cloudy weather had set in at Julpaigori, and this made it impossible to carry on the system of simultaneous star observations at both stations, which is imperatively necessary to secure very precise results in differential longitude determinations.

244. The seven arcs of the current year, combined with the arc Agra–Jubbulpur, which was measured last year, present three verificatory circuits, as follows:—

		m.	s.
Fyzabad–Agra ...	... ...	16	27·932
Fyzabad–Jubbulpur	... ...	8	44·629
Agra–Jubbulpur ...	deduced ...	7	43 303
	measured ...	7	42·993
	Circuit error ...	...	0·310
Hazaribagh–Fyzabad	... ...	12	55·194
Hazaribagh–Jubbulpur	... ...	21	40·908
Fyzabad–Jubbulpur ...	deduced ...	8	45·194
	measured ...	8	44·629
	Circuit error ...	...	0·565
Julpaigori–Hazaribagh	... ...	13	27·071
Julpaigori–Calcutta	... ...	1	30 402
Calcutta–Hazaribagh ...	deduced ...	11	56·669
	measured ...	11	56·724
	Circuit error ...	...	·055

245. The magnitudes of the two first circuit errors are largely in excess of the theoretical probable errors of the operations, and of any errors actually met with hitherto; they clearly indicate the presence either of defects in the instrumental equipment, or of mistakes in the calculations, which are somewhat intricate and troublesome. The performances of the transit instruments had not been nearly so satisfactory as during the preceding years, so that before the calculations of this year's operations were completed and the amounts of the circuit errors were known, these instruments had been sent to the Mathematical Instrument Department in Calcutta for examination. Afterwards, when the circuit errors were known, the observations and calculations were carefully scrutinised, with a view to tracing home all possible causes of sensible error. The analysis of the observations, however, revealed nothing. On the contrary, the results furnished by each arc, *per se*, were on the whole remarkably satisfactory. For instance, as a check on the work, the operations had been executed so as to give results by two distinct methods of procedure: one in which the transits of any star over both meridians are observed by both observers and are recorded on chronographs governed by one and the same clock, the clock at the distant station being telegraphically connected with the chronograph at the observing station for the purpose; the other in which the transits of a star are also observed at both stations, but at each station the transit is recorded in terms of local time, and clock comparisons are made periodically to enable the two sets of observations to be combined. The two methods were independent of each other, excepting as regards the observers and the instruments, which of course were common to both; and this necessitated the application to both of corrections for personal equation and instrumental adjustment, which were based on the same constants, a single set of constants being employed for the whole

of the observations taken on each night. The results by the two methods were in all cases so closely identical, that there would have been no suspicion of error but for the subsequent tests which were afforded on completing and closing the circuits; and then the presence of material latent error became only too apparent.

246. Now it so happened that in the field season of 1872-73, when the electro-telegraphic operations were commenced in India, very discordant results were met with. The officers then conducting the operations were Major Herschel, R.E., and Lieutenant-Colonel Campbell, and they eventually discovered, after long and careful investigation, that the construction of one of the transit telescopes, No. 2, was defective, in that the attachment of the telescope tube to the transit axis was infirm and unstable. The instrument was placed in the hands of the Mathematical Instrument-maker at Madras and rectified, and from that time until now excellent results have been obtained, seven circuits having been completed, of which the average closing error is only $0^s{\cdot}032$. Naturally, therefore, the operations of the present year were commenced without any suspicion of instrumental defects. While they were being carried on, however, some misgivings were felt; and it was therefore decided to send the instruments for thorough examination to the Mathematical Instrument Department at Calcutta as soon as they could be spared, after the conclusion of the field season. It was then found that the instrument, which had originally given trouble, was again in fault, as will now be explained.

247. In order to facilitate transport, the transit telescopes have been constructed in three pieces, the object-end tube, the eye-end tube, and the transit axis, which travel in separate cases. Before being set up for observation, the tubes of the telescope are fixed on the transit axis, for which purpose each tube carries a flange at one end, which can be bolted to the cube of the transit axis. As originally constructed by the makers in England, the tubes were simply soldered to the flange,—a very reprehensible arrangement, seeing that the joint is subject to great strain, arising from the weight of the tube and its appurtenances, which acts with considerable leverage. At Madras the soldering of the object-end tube of No. 2 was found to be giving way, and this was the cause of the bad performance of the instrument, for it introduced instability in the relations between the visual axis and the axis of rotation of the telescope. Here permanence is essentially necessary to satisfactory instrumental performance, because the value of the constants for collimation and level error are only obtained on the assumption of stability at all the joints and constancy in all directions to which the telescope is pointed—whether to stars in the zenith, to the collimators in the horizon, or to the mercury in the nadir. In order to strengthen the instrument, a metal collar was introduced inside the object-end tube and screwed to the flange. The screws passed through the tube, and thus attached it very firmly to the flange. For several years the attachment answered perfectly; but now on examination it has been found to betray signs of weakness, and to an extent that is sufficient to cause the errors which have been met with.

248. The question may naturally be put—why was not the defective state of this instrument found out sooner? The answer is that as yet no means have been invented of readily testing the relations between the visual and the rotatory axes in every position of a transit telescope, with a view to examination from time to time, whenever desirable, and more particularly *pari passu* with the observations that are being taken with the telescope. It is invariably the custom in all the great astronomical observatories, and wherever such instruments are employed, to assume that the axial relations are either absolutely constant, or that they vary systematically by known laws—as of flexure, inequality of pivots, &c.—for which due allowance can be made in reducing the observations. Thus when they happen to be unstable and inconstant, as in the present instance, the discovery of their condition is only made after the conclusion of the observations; and even then it is only made when the operations have been purposely carried out in such a manner as to show up all error, as in the present instance, by the application of the circuit test. It seems, however, to be just possible to provide a means of examining the relations between the visual and rotatory axes, whenever desirable, by fixing a small apparatus outside the object glass to reflect an image of

the wires for comparison with the wires themselves; then, by measuring the distance between the wires and their image, in different positions of the telescope, any inconstancy will at once be shown up. Experiments are being made by Lieutenant-Colonel Campbell with a view to constructing such an apparatus; and though as yet they have not been successful in surmounting the numerous difficulties which have to be overcome, success is still hoped for. If attained, it will far more than outweigh the loss even of all the operations of the present year.

249. It is probable, however, that three or four arcs of this year may, on further testing after the rectification of the defective instrument, be found free from error. It will be noticed that the last circuit of the season exhibits a far smaller error than the two first circuits. The two first lie chiefly in the North-West Provinces. They were measured during the coldest season of the year, when the daily range of temperature from extreme cold to extreme heat was much greater than it was afterwards found to be in Bengal, where the last circuit was measured as the hot season was commencing. Thus the relations between the visual and the rotatory axes of the defective transit telescope, which were probably unstable under the varying temperatures at the commencement of the field season, may have become fairly stable during the warmer and more equable temperature which prevailed towards the close of the season. This would account for the smaller errors latterly met with. Moreover, latterly the observer with No. 2 introduced a method of continuity of direction in the motion of the telescope in passing from the collimation and level observations to the stars, which probably also tended to cancel the evils caused by the defective condition of the telescope.

250. It only remains to state that, on the recent examination in the Mathematical Instrument Department at Calcutta, the attachment of the object-end tube of No. 2 to its flange was strengthened by the application of a more substantial collar than the one introduced at Madras, which has been attached to the flange by numerous screws as well as solder. Similar collars have been applied to the eye-end tube and to both tubes of the sister instrument, in all which the attachments to their respective flanges had hitherto remained in their original condition of dependence on solder alone, and were showing signs of weakness. It is to be hoped that the precautions which have now been taken will prove to be permanently effectual, and that the instruments will be found to be in as serviceable condition hereafter as they proved to be during all but the first and last years of their employment in India.

251. In the coming field season arcs will be measured to furnish an additional check on the operations of last year, and extend them eastwards to Chittagong. Later on, the first arcs of last year will be revised. This arrangement is necessary to permit of the observations at the stations in Bengal and the North-West Provinces being carried on at the times which give best promise of cloudless skies in each locality. As a preliminary to the operations of 1883-84,* pillars will be constructed for the instruments at Akyab, Prome, and Moulmein.

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* Mr. Bond was employed during the season under report in building the transit-pillars in advance at Fyzabad, Hazaribagh, and Jalpaigori, and connecting their sites with the main triangulation, and in revising the connecting triangulation at Agra, which did not contain sufficient checks within itself to be quite satisfactory. The revision showed, however, that the error in the previous determination was insignificant. Mr. Bond's work and conduct were perfectly satisfactory in all points during the season.

Mr. Kodlan joined the party towards the beginning of the recess in place of Mr. Bond, who was transferred to the head-quarters office in Dehra. He was employed in reading off the chronographic sheets and in various computations, and discharged these duties satisfactorily.

Mr. Atkinson was employed under Lieutenant-Colonel Campbell, in No. 1 Astronomical Party, during the recess on computation of the previous season's work, in which he gave satisfaction.

PART II.

THE OPERATIONS AT THE SEVERAL HEAD-QUARTERS OFFICES.

These offices comprise—

(1) The Surveyor General's Office.
(2) The Revenue Survey Office.
(3) The Lithographic Office.
(4) The Photographic Office.
(5) The Mathematical Instrument Office. } All in Calcutta.
(6) The Trigonometrical Survey Office, Dehra Dun.

252. New buildings have been designed for the three other offices in Calcutta in the neighbourhood of the present building. They have not yet been commenced, and will probably not be completed for three years. But what has already been done is of very great value and importance. It has brought the administrative offices together under one roof, which will be of great help in furthering the general amalgamation of the three branches of the department—the trigonometrical, topographical, and revenue—which was commenced in the year 1878, and has as yet been only partially carried out.

Personnel.

Major R. V. Riddell, R.E, Deputy Superintendent, 2nd grade.
J. O. N. James, Esq., Deputy Superintendent, 3rd grade
H. Duhan, Esq., Personal Assistant.

DRAWING BRANCH.

Drawing and Compiling Section.

Mr. W. H. Patterson, Chief Draftsman.
„ J. A. May, Surveyor, 3rd grade.
„ W. Green, Draftsman.
„ J. R Adels „
Munshi Sonaullah „
„ Nabi Baksh „
Mr. A. J. Musgrove, Apprentice.
„ R. C. Sinclair „
„ W. P. Smith „

Geographical Examining Section.

Mr. A. Chamarett, Surveyor, 1st grade.
„ W. Todd „ 2nd „
„ A. J. Wilson „ 2nd „
„ F. Adams „ 3rd „
Baboo Mohesh Chunder Shaw and 2 others.

ENGRAVING BRANCH.

Mr. C. W. Coard, Superintendent.
„ W. Donaldson.
„ G. G. Palmer.
Mr D. L. Mitchell.
„ J. Fulford.
„ T. B. Rogers.
„ A. G. Palmer.
„ S. M. Coard.
„ A. W. N. James.
„ A. R. Coard.
„ A. D. M. Chamarett.
„ E. A. Ollenbach.
25 Native Engravers and 1 Clerk.

Copperplate Printing Section.

Mr. W T. Collins, Copperplate Printer.
14 Native Printers and Pressmen, &c.

CORRESPONDENCE BRANCH.

Mr. T. W. Babonau, Registrar and Accountant.
Mr. M. Francis.
„ F. A. D'Rozario.
„ T. E. Ware.
„ E. D. Algar.
Baboo Banee Madhub Banerjee.
Mr. J. A. Vallis.
Baboo Bheecum Singh, and 9 others.

Map Record and Issue Section.

Mr. R. A. Gibson
„ H. R. Vallis.
„ W. P. Abro and 1 Native Clerk.

253. A few weeks before the close of the year under review the Department of Public Works in Bengal announced that the new building to accommodate the Surveyor-General's and the Revenue Survey offices, which had been under construction for about two and a half years, was ready to be occupied; and within a month after the close of the year the houses in Park Street and Middleton Street, in which the offices had previously been located, were vacated, and the entire stock of maps and records—the collection of nearly a century—copperplates, and plant of all descriptions, was transferred to the new building. This was an undertaking of great labour, extending over about three months, which unfortunately happened to fall in the hot season, and necessitating much forethought and careful arrangements to enable it to be carried on so as to interfere as little as possible with the current work of the office. The supervision of the arrangements for the transfer of the Surveyor-General's office—which was very much the larger of the two, and had long grown beyond the limits of the accommodation afforded by the house in Park Street, in which it had been located for half a century—devolved on Major Riddell and Mr. James; the transfer of the Revenue Survey office

devolved on Major Coddington. The whole of the arrangements were carried out most satisfactorily. The new building has been well designed and admirably constructed. It is commodious and airy; gives sufficient space for all the members of the office, excellent accommodation and lighting for the engravers and draftsmen—the former benefiting more particularly—as they had long been very inconveniently restricted in space, and for the most part were badly lighted.

1.—THE SURVEYOR-GENERAL'S OFFICE.

254. The duties connected with this office are supervised by Major R. V. Riddell, R.E., and Mr. J. O. N. James. Major Riddell conducts the work connected with the management of the topographical parties and their accounts,* and has charge of the Lithographic and the Mathematical Instrument Offices, and Mr. James has the management of the Drawing, Engraving, and Map Despatch Offices.

255. The *Drawing Branch* has been employed on work of the usual kind, viz. compilations on various scales, of maps of India, provincial and district maps, and revisions of old maps from the results of recent surveys. The large demand for the map of India, scale 1 inch = 32 miles, necessitated the issue of a second edition revised up to July 1882. Considerable progress has been made towards completing a series of outline maps of India on the scales of 1 inch = 64 miles, 80 miles, and 96 miles. As these are in great demand to illustrate reports, engraved standards are under preparation, from which prints may be taken for transfer to stone at any time. At the request of the Quartermaster-General in India, a map of Lower Egypt was drawn and published for the use of the troops proceeding from India to Egypt. Maps of the Suez Canal, Cairo, and Alexandria were also printed for the same purpose. All these were in great demand, and large numbers were sold to the public.

256. A new map of Bengal, Behar, and Orissa, with hills, scale 1 inch = 16 miles, has just been printed. Owing to the constant alterations of the boundaries of districts in Bengal, the completion of this map was long delayed; and it was eventually necessary to prepare it for publication by double printing, the boundaries and district names being drawn on one stone, the topographical details and names of towns and villages on another; thus alterations of the frequently varying details may now be carried out without injury to the permanent details, which was impossible when both were drawn on the same stone; and in future new editions of the map may be readily published soon after further changes of boundaries.

Several district maps on the $\frac{1}{4}$-inch scale were prepared for publication; also maps for the North-Western Provinces Gazetteer and drawings for the engravers for new sheets of the Indian atlas. Full details connected with all the work in progress and completed will be found in the usual statement given in the appendix.†

257. The *Examining Branch* continues to render good service in the examination and scrutiny of the mapping rendered each year by field parties of the topographical survey, also of the compilations and drawings prepared in the Drawing Branch, and of all the proofs of prints received from the Engraving, Lithographic, and Photographic branches of the office, which is a very laborious undertaking. Fifty-eight standard sheets of the topographical surveys, 25 original compilations, proofs of 138 engraved maps and of 469 lithographed and photozincographed maps, were examined in addition to other miscellaneous work.‡

258. *Engraving Office.*—The Bengal sheet (No. 4) of the standard map of India has been completed in outline, and the hill-etching will now be taken up; on sheet 5 (Madras presidency) the hills have nearly been completed; the outlines for sheet 6 (Burma and Tenasserim) are complete; sheets 1 and 3 are

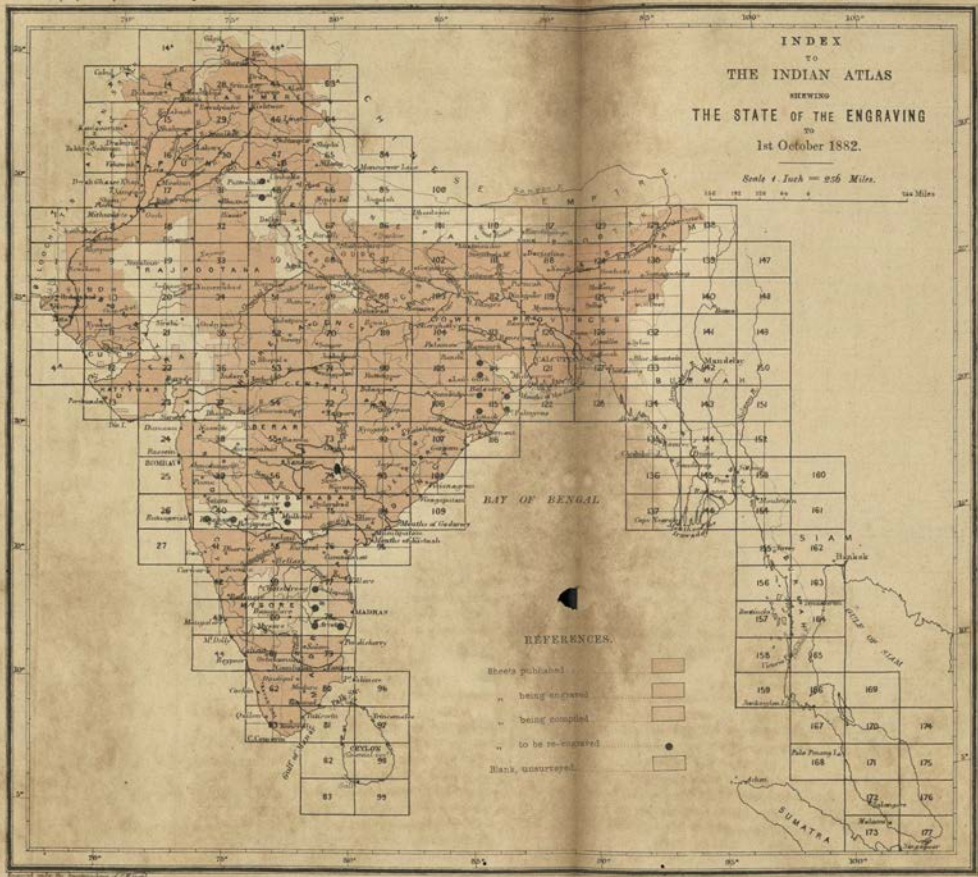
* In the Correspondence Branch Mr. Babonau has performed his multifarious duties as Registrar and Accountant very satisfactorily; Messrs. Francis, D'Rozario, and Ware, and Baboos Banee Madhub Banerjee and Bheecum Singh, have also given entire satisfaction.

† Mr. J. F. Baness, Chief Draftsman in the Drawing Branch, was transferred in March 1882 to the office of the Director-General of Statistics, and Mr. A. Chamarett officiated for him till relieved by Mr. W. H. Patterson on the 8th August. Mr. James reports that both Messrs. Chamarett and Patterson have conducted their duties ably.

Mr. W. Green and Baboo Mohes Chunder Shaw have given satisfaction.

‡ Messrs. Wilson and Adams, and Baboo Purna Chandra Sen, continue to render good aid in the Examining Branch.

To accompany Surveyor General's Report for 1881-82.



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Surveyor General's Office, Calcutta, December 1882.

as yet incomplete as regards portions of Afghanistan, Rajputana, and Central India. Great progress has been made on the hill-etching of the map of India, scale 1 inch = 64 miles, only Afghanistan and a portion of the hills on the Eastern frontier remaining to be finished. The map is expected to be ready for issue by next July or August. The map of the Central Provinces, scale 1 inch = 16 miles, has been completed, with hills. Nine quarter sheets of the Indian Atlas as per margin have been completed during the year. Forty-two others are in different stages of progress; 23 of the old large size full plates have been repaired in part, and have had additions made on them for railways and changes of boundary. Small additions and corrections have been made to other plates. Various other maps of a useful character are in hand, the details connected with the progress of which are given in the statement of work in the appendix. The total out-turn of engraving work is as follows:—2,069 square inches of hill-etching; 362 square inches of minor details, such as forest and sand hills; 3,792 square inches of outline; and 225,576 letters engraved. The hill-etching of the map of India on the scale of 1 inch = 64 miles, and on the new quarter plates of the Himalayan sheets of the Indian Atlas, is highly artistic and effective, and very creditable to the European engravers by whom it has been executed. The steel facing of the copperplates continues to be carried on successfully, and 99 plates have been thus treated before being printed from during the year. The young engravers trained in the office are now by turns employed on this work. In the Copperplate Printing Branch 7,573 impressions of maps were printed, 1,053 proofs were pulled, and 341 transfers prepared for transfer to zinc or stone.*

31 N.-W.	77 N.-E.
32 S.-W.	129 S.-E.
53 N.-W.	130 S.-E.
66 N.-W.	133 N.-W.
67 S.-E.	

259. The work in the *Map Record and Issue section* continues to increase; the map issues and work connected therewith are briefly as follows:—

	Maps.	Value.
		Rs.
To Government officials	45,029	47,120
„ India Office, London	3,015	3,954
„ Agents for sale	10,119	13,392
Total ...	58,163	64,466

Applications received for maps by letters, indents, and telegraphic messages	3,418
Letters issued in reply and as advice of despatch	1,072
Invoices and receipts issued	3,091
Packets, parcels, and packages despatched	3,115

In addition to the above 23,236 sheet maps were coloured by contract for sale and issue, and 7,375 for other departments. The amount realized by map sales through agents and deposited in the Government treasury was Rs. 10,211-10-9.†

260. The work of rearranging, classifying, and cataloguing the original maps is proceeding steadily, and will probably take another year to complete. This work was much needed, not merely as a matter of convenience, to facilitate ready access to any map that might be wanted and to indicate the maps to which reference should be made for specific facts, but because the numerous changes in territorial limits which have taken place in India during the past century caused some difficulty in identifying the portions of country to which they actually refer under the existing territorial divisions of British and Native districts and States. Moreover, the old register volumes in manuscript, which have been in use for the past 60 or 70 years, have become almost illegible from constant use and the fading of the ink. Steps are being taken to print the new register or catalogue in the same form as the catalogue of manuscript and printed reports, field-books, and maps, &c., in the India Office, London.

* In the Engraving Branch the Superintendent, Mr. C. W. Coard, and his European assistants, have worked ably and well, and the native engravers under their tuition are making good progress.

† Mr. R. A. Gibson, Map Curator, is a most useful assistant, and performs his duties ably.

2.—THE REVENUE SURVEY OFFICE.

261. The Revenue Survey Office receives and examines all maps and other professional records executed by the 10 field parties at present constituting the Revenue Survey Branch of the department. This office also has charge of the records of all previous surveys executed by the Revenue Branch, and replies to references connected with these completed surveys. The office likewise supervises the expenditure in the Revenue Branch, and keeps its accounts. A summary of the out-turn of the field work in the several parties of this Branch, with statement of cost and rates, is given at pages 78 and 79. The Statements A and B (pages 85 to 91 of the appendix) exhibit the maps and other records prepared in the field offices and head-quarters office respectively, and Table C (page 92 of the appendix) gives a detailed statement of the number of cadastral maps printed since the commencement of cadastral survey operations, as well as the number printed during the past year.

Personnel.

Lieutenant-Colonel J. Sconce, Deputy Surveyor-General and Superintendent, Revenue Branch.
Major F. Coddington, Deputy Superintendent, 2nd grade.

DRAWING AND COMPUTING BRANCH.

Drawing and Compiling.

Mr. F. W. Kelly, Surveyor on duty.
„ J. Connor, Assistant Surveyor and Draftsman.
Baboo Hari Hur Sen, Head Computer.
„ Tincowry Sen, Computer.
Sheikh Mehir Ali, Draftsman.
„ Golam Mohumud „
„ Abdul Azeez „
„ Rohim Bux „
and 14 others.

Map-examining.

Mr. T. W. Reilly, Surveyor and Draftsman.
Mr. R. C. D. Ewing, Assistant Surveyor and Draftsman.
Sheikh Abdur Rozak, Draftsman.
„ Wahed Bux.

Cadastral Map-examining.

Mr. W. Sinclair, Surveyor and Draftsman, on furlough from 21st April 1882.
Mr. J. H. O'Donel, Surveyor and Draftsman.
Sheikh Kodrut Ally, Draftsman, and six others.

Records and Map issue.

Mr. W. J. Lane, Assistant Surveyor (died on 11th October 1882).
Baboo Ashootosh Ker and one other.

CORRESPONDENCE AND ACCOUNTS BRANCH.

Correspondence.

Mr. A. E. Byrn, Registrar.
„ A. C. Cunningham, Head Clerk.
Baboo Kally Pudo Banerjee, Clerk.
„ Doorga Narain Ghose, do.
„ Ramkisto Chunder, do.
„ Sham Churn Chuckerbutty, Clerk.
Baboo Raj Coomar Dutt, Clerk.
„ Kally Kisto Chunder, Despatcher, and three others.

Accounts.

Mr. Gopal Chunder Laha, Head Accountant.
Baboo Bama Churn Chuckerbutty, Accountant, and two others.

262. The following is a brief review of the summary of the field work as shown in the table at page 78. A column has been added to the table showing the rate of the cadastral surveys per field, besides the usual rate per acre. The general rate for the cadastral surveys in the North-West Provinces is Rs. 138-13-3 per square mile (Re. 0-3-6 per acre), which bears a favourable comparison with Rs. 159-4-11 per square mile (Re. 0-4-0 per acre), the rate for last year. The diminution in the total area surveyed cadastrally in these provinces is accounted for by the withdrawal of one of the three parties hitherto employed. The three cadastral parties in British Burma have surveyed 231 square miles more than last year, and have worked at a cheaper rate, the general rate for the year being Rs. 232-4-9 per square mile (Re. 0-5-10 per acre), against Rs. 250-8-7 per square mile (Re. 0-6-3 per acre) of last year. The rates for the 4-inch surveys in the Punjab are slightly higher on account of the areas—all that remained for survey—being less than last year. The low rate of Rs. 53-6-2 for the 4-inch survey, done for forest purposes in the Bombay presidency, has been obtained by reason of the extent of open country which has been surveyed with the forest lands. A small area of forest reserves in British Burma has been surveyed at a high cost, occasioned by the extremely intricate nature of the country. The topograpical surveys on the 2-inch scale have been accomplished at very similar rates as in previous years. The very low rate of the survey in the southern collectorates of the Deccan is due to the greater part of the country being open and easy for survey. The new topographical survey of the banks of the Hooghly river in the neighbourhood of Calcutta has proved a very tedious and costly undertaking; the intricate village sites lying along the river, and forming the greater part of the area surveyed, have rendered the work more minute than the survey of many a town would be.

263. The following maps, drawn in executive offices, have been examined and published during the year, viz.—

District Rawalpindi, Kala Chitta Pahar	13 sheets on 4-inch scale.
Meerut Division, Topographical Survey	64 sheets on 2-inch scale, for reproduction to scale.
Ditto ditto	76 sections on 2-inch scale, for reduction to 1-inch scale and publication in 19 sheets.
British Burma, district Hanthawaddy	16 sheets on 2-inch scale, for reproduction to scale.
Deccan and Konkan Topographical Survey	36 sheets on 2-inch scale, for reproduction to scale, and the same for reduction to 9 sheets on 1-inch scale.
District Pooree, Killa Khorda	40 sheets on 4-inch scale.
Patna City and Bankipore civil station	2 sheets on 10-inch scale.
Cadastral maps of single villages, in districts in North-West Provinces	2,540 sheets on 16-inch scale.
„ „ in districts in British Burma	2,430 ditto 16-inch do.
„ „ in district Pooree (Bengal)	104 ditto 32-inch do.
„ „ in district Sylhet (Assam)	16 ditto 16-inch do.

264. The following maps, drawn in the Revenue Survey Office, have also been examined and published, viz.—

Dera Ismail Khan	9 sheets on 1-inch scale (drawn in 36 sections on 2-inch scale).
Midnapore	1 sheet on 1-inch scale (drawn in 4 sections on 2-inch scale).
Moradabad and Budaun districts and Rampur State	1 sheet on 1-inch scale (drawn in 4 sections on 2-inch scale).
Oudh districts (new edition)	6 sheets on 1-inch scale.
Noakholly district	11 sheets on 1-inch scale.

265. Besides the examination and drawing of maps as shown above, the time of the draftsmen has been largely occupied, as will be seen from Table B, in supplying copies of miscellaneous maps and records to Government officials. Attention to the demands of private individuals for copies of village plans has engaged a large part of the time of a section of the office. The actual copying of the plans is done at the expense of the applicants, but the labour of identifying the plans according to the descriptions sent falls upon the office draftsmen, and the draftsmen also supervise the copying. Applications for copies of plans come almost exclusively from Bengal.

266. All the records received have been examined and brought on the register of the office, the usual final check on the computations having been carried out for three districts.*

267. The Deputy Surveyor-General acknowledges the very valuable assistance he has received from Major F. Coddington in all matters connected with the administration of the Revenue Branch.

3.—LITHOGRAPHIC BRANCH.

268. The number of maps, plans, and drawings published during the year amounts to 421, of which 267 were undertaken to meet the requirements of other departments, and only 154 for the requirements of the Survey Department.

Personnel.

Major R. V. Riddell, R.E., in charge.
Mr. H. L. Lepage, Head Assistant.
Babu Boloram Nath, Munshi Mahomed Azim, „ Sobhan Buksh, and 22 others, } Draftsmen.
Mr. H. Niven, Chromo-Litho Printer, on leave.
„ J. Watson, „ „ officiating.
1 Press Assistant and 50 others.
Mr. E. D'Pyvah, Type Printer, and 22 others.
Three native clerks.

269. It has been found necessary to commence a reprint of the one-inch scale sheets of Oudh; two sheets have been printed, and several are now in hand; 11 sheets of the one-inch maps of Noakholly have been published.

* Mr. F. W. Kelly, Surveyor, 1st grade, as head of the drawing section of the office, has continued to render excellent service.

Mr. W. Sinclair, Surveyor, 2nd grade, in charge of the cadastral map examination, continued to give entire satisfaction up to the time of his going on furlough. Mr. J. H. O'Donel, Surveyor 4th grade, who took over Mr. Sinclair's duties, has also done very well. Messrs. J. Connor and R. C. D. Ewing, Assistant Surveyors and Draftsmen, have done good and approved work. The office has to regret the loss of Mr. W. J. Lane, Assistant Surveyor and Draftsman, a useful and intelligent officer, who died on the 11th October 1882.

Mr. A. E. Byrn, Mr. A. C. Cunningham, Mr. Gopal Chunder Laha, Baboos Harri Hur Sen, Kally Pudo Banerjee, Doorga Narain Ghose, Ram Kisto Chunder, Bama Churn Chuckerbutty, Tincouri Sen, Sheikhs Meher Ali, Abdul Azeez, and Rohim Bux, together with the rest of the establishment, have all given satisfaction.

The new maps of Bengal with hills, scale 1 inch = 16 miles, which has already been referred to in paragraph 256, was printed on two stones—the topographical and other permanent details in black, the varying district boundaries in red. A preliminary map of the Central Provinces, scale 1 inch = 16 miles, obtained by a transfer to stone from the incomplete engraved plates and the hills in part drawn on stone, has been issued. Six sheets of the Indian Atlas (Nos. 30, 40, 48, 67, 112, and 119), the copperplates of which were in a damaged condition and unfit to repair, were transferred to stone and printed with large additions and corrections. The following district maps were completed:—Seebsaugor, Goalpara, Khulna, Dacca, Sylhet, Beerbhoom, Balaghat, Sonthal Pergunnahs, Kamroop, and Raepore, scale 1 inch = 4 miles; Hoshiarpore, scale 1 inch = 2 miles in four sheets.

270. From other departments 337 subjects comprised in 346 sheets were received for publication, and the value of the work performed amounts to Rs. 20,111.*

4.—THE PHOTOGRAPHIC OFFICE.

271. Major Waterhouse returned from furlough and resumed charge from Major Cowan on the 26th December 1881.

Personnel.

Major J. Waterhouse, B.S.C., Assistant Surveyor-General, in charge.

NEGATIVE BRANCH.

Normal Establishment.

Mr. J. Mackenzie, Photographer.
„ C. DeCruze, Asst. „
Ismail Khan „ „
2 negative retouchers, 2 glass-cleaners, and 1 bhisti.

Cadastral Establishment.

Mr. C. Marshall, Photographer.
„ L. Lagnier „
„ T. Lloyd, Asst. „
4 Assistant Photographers, 3 negative retouchers, 4 glass-cleaners, and 1 bhisti.

PHOTO-TRANSFER PRINTING.

Normal Establishment.

Mr. J. Harrold, Photographer.
Habibul Hossain, Asst. „
2 labourers.

Cadastral Establishment.

Mr. R. George, Photographer.
2 Assistant Photographers and 4 labourers.

SILVER-PRINTING BRANCH.

Normal Establishment.

Mr. G G. Dempster, Photographer.
2 Assistant Photographers and 2 labourers.

ZINC-PRINTING BRANCH.

Normal Establishment.

Mr. B. Mackenzie, Zincographer.
1 writer, 4 zinc correctors, 5 printers, 4 spongemen, 16 pressmen, and 3 grainers.

Cadastral Establishment.

Mr. J. Watson, Zincographer (on deputation) to Litho Branch from 10th April 1882.
Mr. E. A. LeFranc, Zincographer.
1 writer, 8 zinc correctors, 7 printers, 4 spongemen, 15 pressmen, and 6 grainers.

GENERAL OFFICE ESTABLISHMENT.

Normal Establishment.

Baboo Kanny Lall Sen, Store-keeper and Accountant, and 2 clerks.

Cadastral Establishment

Head Assistant (vacant), and one clerk.

272. The out-turn of the office during the year is given in the annexed abstract, and shows a considerable increase in the number of original subjects reproduced, though with a decrease in the number of printed copies, as fewer prints were demanded. Statements showing the comparative out-turn of the present year and the year before, of expenditure and value of work done, and of work done for other departments, are given in the Appendix.

273. The value of the printed maps and other subjects issued during the year has been—

	Rs.
Departmental	28,428
Extra departmental	16,531
Cadastral	69,836
Total ...	1,14,795

The direct expenditure for establishment and stores has been Rs. 93,146, so that the profit to credit of the department amounts to Rs. 21,649.

274. The subjects received for reproduction during the year have been of the usual miscellaneous character. A large number of maps of Egypt and charts of the Red Sea, Suez Canal, Alexandria, Port Said, and Suez were reproduced for the use of the Indian contingent, the military authorities, and the general public. Happily, provision had been made of the best available maps of Egypt and the Suez Canal, chiefly French; and from single copies of these we were able to meet demands till better maps were received from England. The way in which these sudden calls for war maps can be met by photozincography is the best exemplification of its practical value. Of the War Office map in 4 sheets only two copies were received in this country, but by reproducing one

* Mr. H. L. Lepage, Head Assistant, has performed his duties satisfactorily with the aid of Mr. Watson, who has been temporarily transferred from the Photographic Office to supervise the chromo-lithographic printing, *vice* Mr. Niven, absent on leave. Mr. D'Pyvab, type printer, and the native draftsmen and clerks, have worked well.

we were able to supply 400 copies, in 1,600 sheets, of this very useful map in a very short time; besides redrawing it on blue prints and reproducing it on half scale, so as to bring it into one sheet.

275. The number of sheets of cadastral maps printed off and issued during the year was 4,856, which is 311 sheets more than last year, though the number of copies printed is less, owing to the North-Western Provinces Government only requiring 10 copies of each sheet.

276. An improvement has been introduced into the process of intensifying negatives, by which the use of hydrosulphate of ammonia is dispensed with, thus avoiding the very unpleasant smell of this chemical and effecting a very considerable saving in expense. Improvements have also been made in the photo-transfer process by the use of enamelled transfer paper, which gives much sharper prints than the paper ordinarily in use.

277. Some progress has been made in the introduction of heliogravure; an improvement in the method of graining the gelatine reliefs by means of waxed sand, which was effected by Major Waterhouse recently while on furlough, has put the process on a very practical footing for half-tone work. The system of electrotyping adopted at Vienna is found to answer very well, being exceedingly simple and regular in action. There are still some difficulties to overcome in the application of the process to large map work, which have formed the subject of considerable experiment during the year. Two plates of very delicate shaded drawings of basalt crystals have been reproduced, and 800 copies of each printed for the Geological Survey; four more plates of the same kind are in hand. The advantages of the process over lithography for this kind of work are the fidelity with which every touch of the artist is reproduced and the evenness of the printing; the plate, when once steel-faced, yields an almost unlimited number of equally good impressions. The process has been very fully described with all late improvements in Major Waterhouse's report, given in the appendix, in which will also be found further details of the working of the Photographic Office during the year.*

Abstract of Work performed in the Photographic Office from 1st October 1881 to 30th September 1882.

	Original sections or sheets.	Negative plates.	Photographic transfer prints.	Number of plates.	Number of pulls.	Number of printed sheets of each subject. Single.	Number of printed sheets of each subject. Combined.	Silver and other prints.	Cost. Rs.	A.	P.
Topographical maps	162	273	246	71	8,495	8,505	8,505	104	7,189	10	3
Revenue survey maps	300	506	627	80	17,272	17,272	17,272	.....	13,810	7	3
District maps	2	6	.....	2	400	400	400	.....	185	4	9
General maps	4	9	.....	37	6,050	3,350	3,150	27	1,336	0	9
City and cantonment plans	18	53	68	34	4,845	4,865	2,725	.....	2,375	10	7
Miscellaneous, departmental	354	476	320	209	15,805	32,921	27,712	316	19,056	2	11
Ditto extra departmental	420	519	557	367	48,725	57,905	47,565	92	17,968	11	6
Transfers and proofs	.....	.....	.....	.....	2,455	.....	.....	.....	.....		
Total ...	1,260	1,843	1,818	800	99,047	125,218	107,329	533	52,022	0	0
Cadastral, North-Western Provinces.											
Photozincographs	1,920	1,920	1,930	1,931	19,410	19,410	13,310	.....	29,807	9	0
Zincographs	594	.....	.....	594	5,940	5,940	5,630	.....	6,128	2	0
Total ...	2,514	1,920	1,930	2,525	25,350	25,350	18,940	.....	35,935	11	0
Cadastral, British Burma.											
Photozincographs	1,584	1,584	1,605	1,592	54,160	54,160	20,265	.....	25,879	14	0
Zincographs	762	.....	.....	762	26,248	26,248	9,044	.....	8,578	13	0
Total ...	2,346	1,584	1,605	2,354	80,408	80,408	29,309	.....	34,458	11	0
Cadastral, Bengal.											
Photozincographs	104	104	104	104	3,782	3,782	955	.....	1,086	8	0
Zincographs	1	.....	.....	1	50	50	50	.....	13	4	0
Total ...	105	104	104	105	3,832	3,832	1,005	.....	1,099	12	0
Cadastral, Assam.											
Photozincographs	16	16	16	16	400	400	325	.....	244	0	0
Transfers and proofs for cadastral maps ...	.....	.....	.....	.....	9,675	.....	.....	.....	.....		
GRAND TOTAL ...	6,241	5,472	5,473	5,797	218,712	235,208	156,908	533	1,25,269	2	0

* Major Waterhouse reports favourably of his European assistants, Messrs. J. and B. Mackenzie, Harrold Marshall, George, Lagnier, Le Franc, and Dempster, who all continue to work with their usual zeal and steadiness, and of the head clerk, Baboo Kunnya Lal Sen.

5.—THE MATHEMATICAL INSTRUMENT DEPARTMENT.

278. The financial year 1881-82 was a busy period for this Department, especially during the last five months of the year, when the demands, due chiefly to the requirements of railway extension surveys, taxed its resources very heavily.

Personnel.

Major R. V. Riddell, R.E., Superintendent.
Major S. H. Cowan, S.C., Officiating Superintendent, from 3rd July to 2nd October.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument-maker.
Mr. F. Marshall, Assistant Mathematical Instrument-maker.
64 artificers on the permanent establishment.
75 (on an average) artificers on the temporary establishment.

Store Branch.

Mr. G. R. Alderman, Store-keeper.
Baboo Womesh Chunder Chowdhry, Material Store-keeper.
1 Packing sircar.
2 Packers.

Office Branch.

Mr. M. O'Brien, Head Clerk.
„ J. W. Collins, Second Clerk.
6 other permanent clerks.
1 extra clerk.

279. The total number of instruments, &c., received amounted to 26,220. These were valued at Rs. 1,70,080, and the result was derived from the following detail:—4,970 instruments, in value about Rs. 28,130, were received from England; 4,685 were locally purchased at a cost of Rs. 23,390; about 9,010, were manufactured in the workshop at a cost of about Rs. 17,720; about 7,560, valued at Rs. 1,00,850, were received by inter-departmental exchange; of these about 22 per cent were serviceable, and the remainder repairable. The serviceable stock was further increased by the repair on the premises of more than 2,850 instruments (part of the repairable stock), at a cost of a little over Rs. 12,300, which, after repair, were valued at about Rs. 32,120.

280. More than 20,800 instruments, in value very nearly Rs. 1,74,100, were issued during the year, viz.—

	Approximate Number.	Approximate Value.
		Rs.
To the Survey of India Department	7,240	31,620
„ Marine „	320	6,000
„ Telegraph „	190	1,310
„ Military „	400	6,940
„ Public Works „	7,590	1,02,390
„ Educational „	60	490
„ Miscellaneous „	4,250	20,690
„ Road Cess Committees, District Engineers, &c., entitled to receive instruments on payment when they can be spared ...	540	3,820
„ Workshop to complete repairs of instrument	240	820
Total ...	20,830	1,74,080

About 1,570 instruments were repaired for various departments, at a cost of about Rs. 14,100.

281. The total number of instruments issued was very little greater than the number issued during the previous year, but the proportion of expensive instruments having been much greater during the latter year, the total value of the instruments issued was about 50 per cent in excess of the issues of the previous years. This result was caused by the largely increased requirements of the Public Works Department (due, as before stated, to Railway Extension Surveys), to which the average number of instruments issued in the years 1878-79-80-81 was 4,160, at a value of Rs. 35,200; while in the year under report 7,590 instruments were supplied to that Department, at a value of Rs. 1,02,390.

282. The average number of theodolites and levels issued annually during the three years 1878 to 1881 was 88 for the former and 78 for the latter instruments. During the year under report the numbers were 118 and 198 respectively, and more could have been used if they had been available.

283. The stock of instruments locally purchased was exceptionally great; and as it was purchased under very unusual conditions, no comparison can be made with the supply procured from this source in any other year. In the month of August a requisition was received from Burma for a large supply

of instruments for Railway Extension Surveys. Similar demands soon followed from other quarters, and before the end of the calendar year the stock of instruments used in those operations had been completely exhausted; while at the same time a large number of these instruments were still required for immediate use. It is found that the demand could be met to a great extent by local purchases. Consequently, at the end of the month of January application was made to the Government of India, in the Public Works Department, for an extra grant of Rs. 35,000 for the purchase of instruments for that Department. Sanction to this measure was granted in letter No. 538, dated 15th February 1882, from the Under-Secretary to the Government of India to the address of the Surveyor-General; and although by that time the number procurable in the local market was somewhat lower than what had been ascertained to exist in the month of January, purchases to the extent of nearly Rs. 23,800 were made, and the instruments issued before the end of the financial year.

284. The number, class, and cost of the principal instruments purchased are as follows, viz.—

Designation of Instruments.	Number.	Cost.
		Rs.
Chronographs	2	100
Compasses, prismatic	8	715
Glasses, binocular	6	300
Instruments, drawing, in cases, 1st and 2nd sort ...	65	3,730
Ditto, ditto, miscellaneous, single ...	65	727
Lenses, reading	10	41
Levels, dumpy	15	3,950
Pins for maps	3,552	252
Rules, carpenters'	72	147
Do., parallel, of all sorts and sizes	93	1,221
Scales, in sets	68	1,622
Do., single	62	199
Set squares in sets	18	145
Staves, leveling	116	2,463
Tapes, measuring	333	2,195
Theodolites	12	4,272

285. The articles which form the bulk of the manufactures in the workshop, and the cost of their manufactures, are as follows:—

Names of Instruments.	Number.	Cost of manufacture.
		Rs.
Boards, drawing	89	1,182
Chains, measuring	219	2,145
Clinometers, wooden	36	504
Compasses, magnetic, for plane-tables	38	456
Glasses, tracing	6	289
Machines, map-printing	13	696
Pins, for measuring chains	6,000	1,000
Plane-tables	164	1,622
Pluviometers	35	833
Rules, flat	610	328
Do., sight, for plane-tables	247	1,235
Scales, metal	81	850
Squares, optical	12	78
Stands for various instruments	177	1,914
Staves, leveling	25	375
Cases, packing	584	2,784

286. A new lens-polishing machine has been constructed in the workshop. This machine supplies a want which has long been felt. Lenses which would formerly have been condemned as useless can now be restored and be made perfectly serviceable.

287. The total number of instruments repaired in the workshop was a little over 4,400, and the cost of the repairs was Rs. 26,400 very nearly. The principal instruments repaired were as follows, viz.—

Names of Instruments.	Number repaired.
Anemometers	16
Arithmometers	6
Barometers	53
Chains	326
Compasses, magnetic	30
Ditto, prismatic	54
Ditto, surveying	84
Glasses, binocular	17
Instruments, drawing, miscellaneous	965
Instruments, drawing, cases of 1st, 2nd, and 3rd sort	91
Levels, dumpy	171
Rules, flat and parallel	178
Scales	46
Sextants	15
Stands for various instruments.	257
Staves, leveling	218
Tapes	35
Telescopes	31
Theodolites	103

The number of instruments repaired was about 20 per cent less than that repaired during the previous year, but the defect in number is made up in quality; for the number of levels and theodolites (which are among the more intricate class of instruments passing through the workshop) repaired during the year under report was 274, exceeding by 69 the average number of corresponding instruments repaired during the previous three years, although one of them, viz. the year 1878-79, was productive of an exceptionally large out-turn of work.

288. As stated in paragraph 241 of last year's report, three classes of articles in constant demand, in the manufacture of which no great amount of skill is necessary, had been manufactured by artisans in the town, at a cost of about Rs. 845, and endeavours were being made to extend the system. Two more articles, viz. frames for level staves and frames for optical squares, were added to the list of component parts which can be procured in this manner; and although a sum of Rs. 860 only was spent on this class of work, more could have been spent if this Department could have received timely notice of the unusual demands which were made on it during the last half of the financial year 1881-82.

289. The space available at present for the storage of instruments does not admit of a greater stock being kept than is sufficient to meet average demands; and as when an extra large supply of certain classes of instruments is wanted it is generally wanted urgently, it is very desirable that the stock kept ready for issue should be greater than is at present possible. A project for a new building has been sanctioned by Government, and it is believed that the new building is now being designed. When completed, some of the difficulties with which this Department has to contend should be removed; and the sooner it is ready for occupation the better, for it is clear that the work of the Department is increasing.

290. The profit and loss account of the workshop showed a profit of a little over Rs. 300, the charges having amounted to Rs. 45,914, whereas the value of the work done was calculated at Rs. 46,227. Last year, as stated in

paragraph 242 of the annual report, this account showed a loss of about Rs. 1,800. In the year 1879-80 a profit of Rs. 13 was shown, and as the loss in 1880-81 was probably attributed by Major Riddell to the proper source, the results of the three years appear to show that the rates charged by the workshop are as nearly correct as is possible. The cost of the remaining portion of the establishment, including supervision, packing expenses, office accommodation, &c., was about Rs. 19,320, which may be considered to represent the expenses connected with the receipt and issue of about 53,500 instruments, valued at about Rs. 4,24,000.*

6.—THE TRIGONOMETRICAL SURVEY OFFICE.

291. The principal work of this office is the final reduction and publication of the triangulation of all parts of India, and the reproduction of the topographical surveys executed in the Trigonometrical Branch of the Department. The office being located at Dehar Dun, at a considerable distance from Calcutta, has a drawing, a photozincographic, and a printing branch of its own. It is thus independent of all extraneous assistance in the matter of publication, excepting as regards the binding of its printed matter, which has to be done elsewhere, usually at Calcutta. The office has also a depôt of instruments and stores attached to it, chiefly containing the higher class of instruments appertaining to the Great Trigonometrical Survey, of which it has long been the head-quarters office. It is now, and has for many years been, under the immediate and able superintendence of Mr. Hennessey, M.A., F.R.S., aided by Mr. Cole, M.A.

Personnel.

J. B. N. Hennessey, Esq., M.A., F.R.S., Deputy Superintendent, 1st grade, in charge.
W. H. Cole, Esq., M.A., Deputy Superintendent, 4th grade.

Computing Branch.

Mr. C. Wood, Surveyor, 2nd grade.
„ H. W. Peychers, Surveyor, 4th grade.
Baboo Gunga Purshad, Computer.
„ Kally Mohun Ghose, do.
„ Kally Coomar Chatterjee, Computer.
10 other Computers, &c.

Printing Branch.

Mr. B. V. Hughes, Printer.
13 compositors and apprentices.

Correspondence, Stores, &c.

Mr. H. E. T. Keelan, Surveyor, 2nd grade (to 1st July).
Mr. J. Bond, Assistant Surveyor, 1st grade (from 1st July).
2 native writers.

Photozincographic Branch.

Mr. C. G. Ollenbach, Zincographer.
„ C. Dyson, Photographer.
2 Native Draftsmen.
1 Assistant Draftsman.
1 Map-keeper.

Drawing Branch.

Mr. G. W. E. Atkinson, Surveyor, 2nd grade.
Jafer Khan and 6 other Draftsmen.
19 Assistant Draftsmen and Map colourists.

Solar Photography.

Mr. L. H. Clarke, Surveyor, 2nd grade, and Solar Photographer.
Mr. C. F. Guthrie, Assistant to ditto.

292. The more important calculations of the year were those in connection with—(1) the Southern Trigon, which comprises the whole of the principal triangulation south of $18\frac{1}{2}^{\circ}$; (2) the observed latitudes; (3) the Assam Longitudinal Series and Assam Valley triangulation. Much assistance was also rendered in bringing up the field computations of the Eastern Frontier Series, including the principal triangulation, the Mergui base-line, the astronomical observations at Mergui and Moulmein, and the Burma secondary operations, all which were carried on with a view to facilitate the final reductions to be made hereafter. The Gilghit triangulation by Colonel Tanner was also computed, various tables were prepared for the details of the North-East Quadrilateral, which are given in Volume VII of the final account of the principal triangulation, and some secondary operations were finally adjusted and reduced.

293. The reduction of the Southern Trigon by the simultaneous method adopted for the three preceding Quadrilaterals was commenced last year, and has been completed this year, very satisfactorily, as appears from the values of the residual errors which are given in the appendix. The auxiliary figures now alone remain for adjustment.

294. The final reduction of all the Astronomical latitudes observed up to date in connection with the geodetic operations of this survey is reported to have made good progress, "in keeping with the fact that under pressure to meet immediate wants only one pair of computers could be employed on the work, and that for little over half the year. The reduction, moreover, presents a considerable undertaking, involving, as it does, observations to

* Major Riddell reports that he is well satisfied with the work of Mr. T. Bolton, the Instrument-maker, and with that of Mr. T. Marshall, the Assistant Mathematical Instrument-maker, who is a very useful acquisition to the workshop. The store-keeper and office clerks have worked assiduously and as successfully as can be expected

large groups out of 906 stars at 117 stations, so that more rapid progress under the circumstances was not practicable. Contributions towards the volume of latitudes, to be printed, have been secured to the extent of description by Lieutenant-Colonel Campbell of Strange's zenith sector, with drawings of the same instrument by Major G. Strahan." The final reductions depend on an elaborate analysis by Mr. Hennessey of the several values of the places of the observed stars, which are given in the various published catalogues of stars' places, sometimes with material differences between different catalogues.

295. Volume VII of the Account of the Operations of the Great Trigonometrical Survey was completed and placed in the hands of the book-binders by the close of the year under review. Volumes VII and VIII are devoted to the several chains of triangles—sixteen in number—comprised in the North-East Quadrilateral, the great geodetic figure, which—speaking broadly—covers the area included, from north to south, between the Himalayan mountains and the parallel of Calcutta, and from west to east, between the Central Indian meridian and the Eastern frontier. Volume VII gives full details of the simultaneous reduction of all the chains of triangles, an operation which was performed under the immediate direction of Major Herschel, R.E., F.R.S., during the absence of Mr. Hennessey in Europe, and the details of five out of sixteen of the included chains of triangles. Volume VIII gives the details of the remaining eleven chains. It was completed and placed in the hands of the book-binders by Christmas 1882. While these pages are being passed through the press, both volumes are being distributed to the principal scientific libraries and geodesists in all quarters of the globe.

296. It had been intended that Volume IX, the next for publication, should be devoted to the details of the astronomical observations for latitude and their final reduction; but delays occurred to prevent this intention from being carried out. Meanwhile considerable progress had been made by Lieutenant-Colonel Campbell in the preparation of the volume which is to give an account of the electro-telegraphic determinations of differences of longitude. The printing of this volume has therefore been pressed forward. 290 additional pages have been printed, and the volume will probably be ready for issue by April 1883. It will be published as Volume IX of the series.

297. Of the Synoptical Volumes, which give a *précis* of the results of the whole of the triangulation, both principal and secondary, for the requirements of topographers and geographers, Volumes VII, X, XI, XII, and XIII have been distributed, and progress has been made with the volumes of the Assam Longitudinal Series and Assam Valley triangulation, and of the Gurwani Series.

298. In the report for last year it was pointed out that the lines of spirit levels in the Bombay and Madras presidencies, which connect the tidal stations at Okha—near the entrance to the Gulf of Cutch—Bombay, Karwar, and Madras, present the anomaly of raising the southern points relatively to the northern, and that this is probably due to an accumulation of minute errors caused by oblique illumination of the bubbles of the spirit levels. It was also stated that the mean-sea level, as determined at each tidal station, would be assumed to be the datum to which the spirit levels should be referred in each instance, and that any discrepancy which might be met with on closing a line of levels at a tidal station (purely oceanic and not riverain) would be dispersed over the line and treated as an error generated in the leveling operations. In accordance with this arrangement, the lines of levels connecting Bombay, Karwar, and Madras have been adjusted simultaneously by the method of least squares; pamphlet No. 4 of Heights in Southern India from the Spirit-leveling operations has been prepared and is in press, and suitably amended issues will be made of the pamphlets previously published.

299. The sheets 75 and 82 of the charts of spirit levels, which were drawn in 1880-81, have been printed and distributed, and four other sheets are in hand. Additional data have also been collected from several districts in Bengal, and will serve to illustrate the sheets of that province, not issued hitherto from want of material. It is hoped that several additional sheets will be ready for publication next year.

300. A new edition, the sixth, of the map of Turkestan is under compilation, in communication with the Foreign Department, to which proofs of the

map have already been submitted. It is intended to include all the geographical information received up to date from officers and explorers of the Survey Department, notably from the recent operations in Afghanistan, Colonel Tanner's surveys around Gilghit, and the work of explorer M— S— in and around Badakhshán, and from all other available sources—as Regel's (part of) Darwaz 1882; Schindler's Routes, Persia, 1880; Floyer's Beluchistan, 1882; Turkestan Military Circuit (Russian Topographical Department), 1880-81, &c.

301. All the maps of the current year's work of the Guzerat and Cutch parties have been examined and published; a few preliminary charts of triangulation have been compiled and published, but of course this work has been materially diminishing of late years, as the field operations have been gradually coming to an end; but a large amount of miscellaneous work has been executed, as detailed in the appendix. For the Forest Survey Department 17 maps and 1 chart were passed to press and published. The money paid to this office for maps and charts during the year was Rs. 743.

302. The Colby apparatus of compensation bars and microscopes and its appurtenances—including standard bar A, with which comparisons of length have been made at all the base-lines—is always lodged for protection in the office at Dehra when not actually in use. Fourteen years having elapsed since the measurement of the Cape Camorin base-line, when it was last employed, it had to be carefully examined and put into good working order before being sent to Mergui for the base-line, which was measured there this year. This was done by Mr. Hennessey conjointly with Colonel Branfill.

303. The important duty of watching over the protection of the principal stations of the Great Trigonometrical Survey continues to be carried on. In all there are 3,472 stations in 338 districts, involving correspondence and accounts with each district officer. During the year 764 stations were specially protected or repaired, at an average cost of Rs. 4-8 per station. Of the district officers who should have sent annual reports, about one-sixth failed to comply.

304. Mr. Hennessey reports that "various scientific duties continue to present themselves for discharge, with a growing tendency." Meteorological observations at Dehra and Mussooree are of long standing. These were taken during the year, as usual, and a daily weather-telegram was sent from Mussooree to the Meteorological Reporter to the Government of India during the months of April to November. Earth temperatures have been observed daily, and the mean monthly results for about a year and a half will be found in the appendix. Actinometry was commenced in 1869 by Mr. Hennessey, who has subsequently also availed himself of favourable opportunities when at Mussooree to observe: occasional measurements were made last year: four of the assistants, two being natives, are now able to use the instrument. Mr. Hennessey's results have been published and discussed in various numbers of the proceedings of the Royal Society, and the subject having attracted attention of the Solar Physics Committee, South Kensington, the Secretary of State has sent out Sergeant Rowland, R.E., to act under the Meteorological Reporter to the Government of India in taking a series of observations at Leh, extending over two years or more. Mr. Blanford has placed the Serjeant temporarily under Mr. Hennessey, who is instructing him and arranging for the required work. As one of the miscellaneous items may be mentioned an appeal from Professor Schuster, Secretary to the Meteoric Committee, presided over by Sir William Thomson, for collecting evidence as to the presence of well-known meteoric components deposited as dust on the earth's surface, for assistance in procuring *desert* sand and condensed water from *untrodden* snow—a request which has already been complied with in respect to sand, but has not yet been found practicable as regards snow.

305. The explorer M— S— having returned after nearly four years' absence from India with valuable traverses in and around Badakhshán, his journal and itinerary have been translated; and the illustrating sketch map prepared, which is given in section XXVI of Part I of the present report.

306. Solar photographs for the Solar Physics Committee, South Kensington, were taken on every day of the year when the sun was visible: invisibility occurred only to the extent of 10 per cent, against 15 in the year previous. Solar features appeared on every day of visibility, besides that a remarkable exhibit of large spots occurred in April. The spots were

depicted in a daily series of negatives, fortunately without any break. The photoheliograph in use is the old instrument, giving 4-inch images of the sun: for a short time the instrument was employed with an enlarging apparatus giving 8-inch images; but intimation being received from General Strachey that the Astronomer Royal requires 4-inch negatives for the measuring apparatus at Greenwich, a reversion has been made to the smaller sized pictures. The new large photoheliograph for taking 12-inch negatives has been received safely. The observatory for its accommodation is now well advanced, and it is expected that the instrument will shortly be in working order.*

* Mr. Hennessey acknowledges the valuable and efficient aid he has received from Mr. Cole in direction as well as in execution, more particularly in regard to the completion of Volume VII.

Mr. Wood is commended for the willingness and ability with which he has discharged a great variety of duties.

The work of Mr. Peychers, Baboos Gunga Pershad and Cally Mohan Ghose, in the Computing Branch, is reported on very favourably.

Messrs. Keelan, Atkinson, Clarke, Ollenbach, Hughes, and Dyson, are also commended.

Summary of Out-turn of Work executed by the TRIGONOMETRICAL PARTIES during the survey year 1881-82.

Description of Details.	Bombay Party, 24" theodolite.	Eastern Frontier Series, 24" theodolite.	Spirit-leveling operations.*	Total.
Number of principal stations newly fixed	8	7	.....	15
" " triangles completed	7	8	.....	15
Length of principal series in miles	15	94	.....	109
Area of principal triangulation in square miles ...	21	1,667	.....	1,688
Average triangular error in seconds	0·47	0·73	.....	.....
" probable error of angles in seconds ...	·03	·06	.....	.....
Astronomical azimuths of verification	3	1	.....	4
" latitude	4	3	.....	7
Number of principal stations selected in advance ...	.....	10	.....	10
" of platforms constructed for principal stations	.....	7	.....	7
Number of principal stations placed under official protection and protected	.....	11	.....	11
Number of principal stations the elements of which have been computed	.....	17	.....	17
Number of secondary triangles of which all three angles have been observed	8	.....	.....	8
Area embraced by triangulation to prominent points exterior to principal triangulation and in square miles	282	3,062	.....	3,344
Number of points fixed by intersection but not visited	11	37	.....	48
Number of stations and points, the heights of which have been determined	9	35	9	53
Number of miles of rays and pathways cleared ...	.....	23	.....	23
" of preliminary charts of triangulation ...	1	.....	.....	1
" of hill tops cleared of forest or jungle ...	.....	7	.....	7
" of miles leveled over	23	.....	448	471
" of permanent bench-mark stones embedded	2	.....	24	26
Number of trigonometrical stations connected with lines of levels	4	.....	11	15
Number of other permanent points fixed as bench-marks	6	.....	286	292

* In addition to the above, 128 miles of leveling were executed by the Hanthawaddy Revenue Branch Party in British Burma, fixing the heights of 129 bench-marks, of which 57 were on posts specially embedded, the remainder being on trees and other previously existing objects.

Summary of Out-turn of the TOPOGRAPHICAL

Scale of survey.	Topographical Survey.	Instrument used.	Area triangulated in square miles.	Number of stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	TRIANGULATION. 1ST CLASS TRIANGULATION, IN WHICH EACH ANGLE IS USUALLY OBSERVED ON FOUR ZEROS, OR MORE. Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	2ND CLASS TRIANGULATION, IN WHICH EACH ANGLE IS USUALLY OBSERVED ON TWO ZEROS. Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	3RD CLASS OR TERTIARY TRIANGULATION, IN WHICH TWO ANGLES ONLY OF EACH TRIANGLE ARE OBSERVED. Number of intersected points.	Number of triangles.	Error per mile in feet.	Number of heights.	Number of extra heights determined by barometrical observations or otherwise.
1 inch = 2 miles.	No. 7 Party, Rajputana ...	12"	3,500	36	10·7	13·7	...	...	...	...	...	8	25	7·1	0·35	21	292	450	0·84	220	...
1 inch = 1 mile.	No. 1 Gwalior and Central India.	12	1,624	34	6·3	8·3	...	...	...	...	...	21	104	5·1	0·11	21	243	440	0·69	160	6
	No. 5 Bhopal and Malwa ..	14	1,091	19	8	10·	...	...	...	...	...	11	32	2·7	0·19	11	112	227	0·91	84	...
	No. 8 Party, Mysore ...	.....	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1,323
	Kohat Survey	6	1,000	24	12·5	6·8	...	...	...	...	...	17	27	24	0·5	17	65	141	1·3	128	18
2 inches = 1 mile.	No. 2 Party, Khandesh and Bombay Native States.	10	490	26	3·8	4·6	21	58	9·0	0·63	23	...	...	...	...	...	102	155	2·0	68	...
	Guzerat	10" and 6"	1,705	79	3·0	5·4	...	...	...	...	...	53	116	7·9	0·25	53	348	475	1·5	151	133
	Cutch	7	1,377	78	1·8	...	...	...	...	...	...	72	159	8·6	0·3	63	691	1,260	0·8	561	14
6 inches.	No. 5 Bhopal and Malwa...	6	10	3	7	4·3	...	...	...	...	...	7	10	13·1	0·41	7	69	133	...	36	...

PARTIES between the 1st October 1881 and 30th September 1882.

Scale of Survey.	Topographical Survey.	Traverse. Instrument used.	Traverse. Number of stations at which the Theodolite was set up.	Traverse. Linear miles, simple traversing.	Traverse. Linear miles, Boundary survey.	Traverse. Average angular error per station in seconds.	Traverse. Average error per 1,000 links in links.	Traverse. Number of village trijunctions fixed.	Traverse. Number of plane-table points fixed.	Topography. Final topography completed during the season, in square miles.	Topography. Average number of plane-table fixings per square mile.	Topography. Number of linear miles of test lines by which each year's work has been tested.	Names of districts, &c., through which the season's operations have been carried.	Area of triangulation in advance of topography, square miles.
1 inch = 2 miles.	No. 6 Party, North-Eastern Frontier Survey.	.....	...	...	...	...	...	...	...	222	0·25	.....	Hill Tipperah	...
	No. 7 Party, Rajputana ...	.....	...	...	...	...	...	...	...	5611·3	1·2	.....	Jodhpur, Mallani, and a small portion of Jeysulmere.	5,500
	Cutch	.....	...	...	...	...	...	...	...	598	.....	.....	Cutch	...
										6431·3				
1 inch = 1 mile.	No. 1 Party, Gwalior and Central India.	.....	...	...	...	...	...	...	...	2440	7·5	96	Marwar, Serohi, and Mewar	3,420
	No. 5 Party, Bhopal and Malwa.	.....	...	...	...	...	...	...	...	1071·5	7·1	16·5	Banswara, Ruttam, Sailana, Gwalior, Khando, Kusalgarh, Partabgarh, Jaora, Piplanda, Udeypur, and Dongarpur.	1,610
	No. 8 Party, Mysore	.....	...	...	...	...	...	...	...	4,220	10·3	423·2	Shimoga, Kadur, Hasan, Chittaldroog, and Tumkur.	9,091
	Kohat Survey	.....	...	...	...	...	...	...	...	1343·8	5·2	51	Kohat	7,800
										9081·3				
2 inches = 1 mile.	No. 2 Party, Khandesh and Bombay Native States.	5"	1,903	1,021	...	3·5	2·8	1,054	...	1552·5	20	276	Khandesh and boundary of Nizam's dominions.	1,490
	No. 6 Party, North-Eastern Frontier.	.....	...	...	1,046	...	...	...	...	244	2·5	.....	South Sylhet	...
	Guzerat	7," 6," and 5"	934	91·8	79·4	13·48	2·7	...	...	1257·4	23·7	563·2	Parts of Chikli, Balsar, and Pardi, Talukas of the Surat district and Baroda and Bansda States.	3,468
	Cutch	5"	686	623	...	11·8	1·2	...	...	1,619	7·3	621·9	Cutch	1,877
										4702·9				
4"	Guzerat	.....	...	...	...	...	...	...	...	152·3	50·4	7·5	Dang Forest	190
6"	No. 5, Bhopal and Malwa ...	6	21	12·18	...	6	0·80	...	...	20·2	.....	6·7	Banswara, Jaora, cities ...	...
12"	Guzerat	.....	..	...	...	...	...	...	...	24·90	112·3	6·25	Chaorasi taluka, Surat district, and Sachin State.	...

Summary of the Outturn of the Field Work of the REVENUE BRANCH

Designation of Survey Party.	Scale of Survey.	Where Employed. Province.	District.	Number of villages.	Area Completed. Topography and detail.	Traverse. In advance.	Triangulation. In advance.
					Cadastral Surveys.		
					Sqr miles.	Sq. miles.	Sq. miles.
No. 4 party	16 inches = 1 mile... Ditto	North-Western Provinces ...	Ghazipur	964	225	.....	.....
	Ditto	Ditto ...	Ballia	1,177	410(b)	163	.....
	Ditto	Ditto ...	Benares	.....	.....	279	.....
,, 6 ,, ...	Ditto	Ditto ...	Mirzapur	645	734	319	.....
	Ditto	Ditto ...	Tarai	19	16	.....	.....
,, 2 ,, ...	Ditto	British Burma	Hanthawaddy	418	744	458	.....
	Ditto	Ditto	Rangoon Town	.....	19	.....	.....
,, 7 ,, ...	Ditto	Ditto	Tharrawaddy	230	526	226	.....
	Ditto	Ditto	Prome	.....	.....		.....
,, 8 ,, ...	Ditto	Ditto	Bassein	519	813(g)	350	.....
Sylhet test survey.	Ditto	Assam	Sylhet	59	26	.....	.....
			TOTAL OF CADASTRAL SURVEYS ...	3,722	3,813	1,754	.....
					Mauzawar, Riverain, and Forest Surveys.		
No. 1 party	4 inches = 1 mile ... Ditto	Punjab	Dera Ismail Khan	23	689	.....	.....
	Ditto	Ditto	Muzaffargarh	43	785	.....	.....
	Ditto	Ditto	Rawalpindi	.....	390	.....	.....
	Ditto	Ditto	Sialkot (Chenab river)	.....	11	.....	.....
,, 3 ,, ...	Ditto	North-Western Provinces	Bulandshahr (adjoining Ganges and Jumna rivers).	.....	457	.....	.....
,, 4 ,, ...	Ditto	Bengal	Shahabad (adjoining Ganges river)	66	31	.....	.....
,, 7 ,, ...	Ditto	British Burma	Tharrawaddy	.....	43	25	.....
,, 10 ,, ...	Ditto	Bombay	Thana	.....	940	450	.....
			TOTAL OF MAUZAWAR, RIVERAIN, AND FOREST SURVEYS ...	.....	3,948	475	.....
					Topographical Surveys.		
No. 3 party	2 inches = 1 mile... Ditto	North-Western Provinces	Meerut	.....	335	.....	.....
	Ditto	Ditto	Bulandshahr	.....	1,173	.....	.....
	Ditto	Ditto	Aligarh	.....	.....	1,385	.....
,, 11 ,, ...	Ditto	Bombay	Southern Collectorates of Deccan	.....	2,974	2,026	2,880
,, 6 ,, ...	16 Ditto	Bengal	Hooghly and 24-Pergunnahs ...	.....	53	63	.....
	6 Ditto	Ditto	Ditto ditto ...	.....	14		
,, 2 ,, ...	2 Ditto	British Burma	Hanthawaddy	.....	92	42	.....
,, 7 ,, ...	Ditto	Ditto	Tharrawaddy	.....	197	.....	.....
,, 5 ,, ...	Ditto	North-Western Provinces	Mirzapur	.....	.....	.....	1,790
			TOTAL OF TOPOGRAPHICAL SURVEYS ...	.....	3,816	3,506	4,670
No. 11 party...	80 inches = 1 mile ...	Sholapur City	.....	.....	1(c)	.....	.....
			GRAND TOTAL ...	.....	10,575	5,755	4,670

Abstract according to Jurisdictions.

Province.	Scale of Survey.	Area surveyed in square miles.	Cost.	Average rate per square mile.	Remarks.
			Rs. A. P.	Rs. A. P.	
North-Western Provinces	2 inches = 1 mile...	1,496	47,720 0 3	29 0 1	Rate is exclusive of Rs. 5,769-1-9, the cost of Mirzapur triangulation in advance.
	4 do. = 1 do. ...	157	6,965 10 4	44 5 10	
	16 do. = 1 do. ...	3,385	1,92,277 0 7	188 13 3	Cadastral.
Punjab	4 do. = 1 do. ...	1,575	35,688 13 5	29 10 11	
Bengal	4 do. = 1 do. ...	31	1,691 0 0	54 9 10	
	6 do. = 1 do. ...	14	4,250 0 0	309 4 7	This work is equivalent to a city survey.
	16 do. = 1 do. ...	23	46,765 11 4	1,735 6 8	
Assam	16 do. = 1 do. ...	26	18,067 0 11	694 14 2	Cadastral special test survey.
British Burma	2 do. = 1 do. ...	199	11,543 11 2	58 0 3	
	4 do. = 1 do. ...	42	18,775 10 8	447 0 8	
	16 do. = 1 do. ...	2,103	6,81,298 1 6	232 4 9	Cadastral.
Bombay	2 do. = 1 do. ...	2,074	47,458 5 0	22 14 1	
	4 do. = 1 do. ...	946	50,190 12 2	53 0 2	
	80 do. = 1 do. ...	1	.....	.....	Cost = Rs. 5,916, paid by Sholapur Municipality.
	TOTAL ...	10,575	9,83,731 13 4	.....	

DEPUTY SURVEYOR-GENERAL'S OFFICE,

Calcutta, the 1st October 1882.

PARTIES between 1st October 1881 to 30th September 1882.

Designation of Survey Party.	Cost.	Rate. Per acre.	Rate. Per field.	Number of fields.	Average size of fields.	Remarks.
	Rs. A. P.	Rs. A. P.	Rs. A. P.		Acre.	
No. 4 party ...	93,093 2 6(a)	0 3 5	0 1 6	988,167	0·41	(a) The cost is exclusive of Rs. 325 spent in surveying 12·5 square miles of overlap on 2" scale on district Azamgarh.
„ 5 „ ...	26,537 13 5(c)	0 3 3	0 4 5	346,140	0·67(h)	(b) Of this area 4 square miles were surveyed on the 32" scale.
	2,646 0 8	0 4 2	0 5 3	8,034	1·27	(c) Exclusive of Rs. 3,450 expended on theodolite mark-stones.
„ 2 „ ...	3,72,344 10. 1(d)	0 5 8	0 5 5	509,763	0·43(n)	(d) Exclusive of Rs. 1,701-6-9 expended on demarcation and Rs. 13,342-2-2 paid by Forest Department.
„ ½ „ ...	1,36,375 4 11(e)	0 6 5	0 4 4	497,000	0·30(k)	(e) Exclusive of Rs. 4,434-2-3 expended on demarcation.
„ 3 „ ...	1,79,771 2 6(f)	0 5 6	0 8 2	349,590	0·44(k)	(f) The topography of 3½ square miles was surveyed on the 2" scale.
Sylhet test survey.	18,067 0 11	1 1 6	0 5 9	49,825	0·33	(k) The average size of fields is on the cultivated portion only.
	6,98,635 3 0					(i) Of this amount Rs. 19,624 have been debited against the Forest Department.
		Per square mile.				(j) Special survey by a selected European officer.
		Rs. A. P.				(k) Very intricate forest-clad country.
No. 1 party ...	29,479 10 7	17 9 9				(l) Exclusive of charge for October 1881, which was included in the Return of 1880-81.
	24,703 2 10	120 0 3				(m) The numerous village sites on the banks of the Hooghly river rendered the work equivalent to a city survey.
	1,476 0 0	124 2 11(j)				(n) The average size of fields is on the gross area.
„ 3 „ ...	6,965 10 4	44 5 10				(o) The intermediate lands lying between the city and detached bazars have also been mapped, adding 1,571 acres to the area of the survey. Total area mapped = 3 square miles nearly. Actual city area = 124 acres.
„ 4 „ ...	1,693 0 0	54 9 10				*Note.*—The rates in the 5th, 6th, 7th, and 8th divisions are exclusive of the following :—
„ 7 „ ...	18,775 10 8	447 0 8(k)				Rs. A. P.
„ 10 „ ...	50,180 12 2(l)	53 6 2				No. 5 party ... 1,006 12 9 Leave and furlough allowance of European assistants.
	1,33,273 14 7					„ 6 „ ... 2,692 11 4 Leave and travelling allowance.
						„ 7 „ ... 603 0 0 Furlough allowance.
						„ 8 „ ... 1,170 0 0 Ditto ditto.
No. 3 party ...	43,950 14 6	29 6 1				
„ 11 party ...	47,458 5 0	22 14 1				
		Per acre.				
„ 6 „ ...	40,763 11 4 (i)	1 12 11 (m)				
	4,330 0 0 (i)	0 7 7½				
		Per sqr. mile.				
„ 2 „ ...	3,500 0 0	35 13 11				
„ 7 „ ...	9,247 11 2	77 A 0				
„ 8 „ ...	3,709 1 9	2 1 8				
	1,51,822 11 9					
	..... (p)					(p) Cost = Rs. 5,916, paid by Sholapur Municipality. Average rate = Rs. 311-11 per acre.
	9,83,731 13 4					

Districts completed since last Report.

District.	Number of villages.	Number of fields.	Area in square miles.	Cost inclusive of all expenditure.	Final rate per square mile.	Nature of survey: by whom and when surveyed.	Remarks.
				Rs.	Rs. A. P.		
Ghazipur	3,774	1,061,232 (average size of the fields = 0·48 of an acre.)	1,456	2,53,343	169 11 1	Surveyed cadastrally on the scale of 16 inches to a mile by Major W. Barron: commenced, 1878-79; finished, 1881-82.	
Dera Ismail Khan ...	911	.....	9,551	2,90,756	31 6 2	Surveyed Manzawar on the scale of 4 inches to a mile by Colonel H. C. Johnstone, Captain H. E. Smith, and Lieutenant-Colonel D. Macdonald: commenced, 1878-79; finished, 1881-82.	Includes 112 square miles of country lying between settlement boundary and base of hills.
Meerut	.....	.....	2,586	79,309	33 3 2	Surveyed topographically on the scale of 2 inches to a mile by Major W. H. Wilkins and Mr. B. T. S. Johnson: commenced, 1879-80; finished, 1881-82. A line of villages, in area 174 square miles, along the Jumna river, has been surveyed on the scale of 4 inches to a mile.	Excluding the 4-inch survey, the cost rate of the 2-inch survey is Rs. 31-11-3 per square mile.

J. E. SANDEMAN, *Major*,
for Deputy Surveyor-General.

APPENDIX.

EXTRACTS

FROM

THE NARRATIVE REPORTS OF THE EXECUTIVE OFFICERS

IN CHARGE OF

THE SURVEY PARTIES AND OPERATIONS.

134596

Extract from the Narrative Report, dated 27th October 1882, *of* LIEUTENANT-COLONEL B. R. BRANFILL, B.C., *Deputy Superintendent, Survey of India, in charge Bombay Party.*

Preliminary.

THE Eastern Sind series having been completed by the Bombay party during last field season, and the computations connected with it very nearly so during the recess, I received instructions to examine and prepare the base-line measuring apparatus for the Mergui base, which it was determined to measure during the field season of 1881-82.

In carrying out this duty at Dehra, I received every assistance from Mr. Hennessey, who placed the workshop resources of the Dehra office at my disposal and gave me all the information and instructions requisite. The apparatus was found to be worn and shaky, but was put into efficient working order, cleaned and adjusted throughout by the middle of October, when it was packed up and despatched by rail to Calcutta.

Government steamer *Celerity*.

The Indian Government steamer *Celerity* had been provided to aid in pushing on the triangulation to the southward of the base-line in the Mergui Archipelago, and the whole of the Bombay party, with its ordinary camp equipage and triangulating instruments, proceeded in this vessel from Calcutta to Rangoon on the 5th November.

As there was no stowage room for it in the *Celerity*, the whole of the base-line apparatus had to be despatched by the ordinary coasting steamer of the British India Steam Navigation Company, which left on the 4th November bound for Mergui, accompanied by Mr. Atkinson and two natives to look after the measuring bars and instruments.

A steam-launch found to be very desirable.

In view of the shallows and sunken rocks with which the Mergui Archipelago abounds, and the great draught of water of the *Celerity* (nearly 12 feet), which would preclude any near approach to the shore generally, and prevent her entirely from traversing many of the channels, Captain Searle, Superintendent of Marine, strongly urged that we should obtain the use of the steam-launch *Moulmein*, which was being sent in tow of the *Celerity* from Calcutta to Rangoon for the use of the port of Moulmein. He also urged this course as a matter of great economy in the expenditure of coal, inasmuch as the *Celerity* could carry comparatively little fuel for her own relatively large consumption, and the party would be deprived of the aid of steam power entirely whilst she was proceeding to and fro to recoal, whereas the steam-launch only consumed about one-tenth the amount of fuel, and was actually more suitable for the many coasting trips that were necessary in visiting the survey stations. Moreover, the steam-launch could be manned and worked by the crew of the *Celerity* without any extra expense.

Steam-launch obtained at Rangoon.

On the 10th the *Celerity* put into Rangoon, the last port where there was a depôt of fuel to recoal, and whilst there, with your sanction, I applied for and obtained the use of the steam-launch for the ensuing two months at the rate of Rs. 500 a month. I am glad to state that this arrangement, in the opinion of those engaged in the operations, proved eminently convenient and economical.

The party reaches Mergui.

On the 12th November the *Celerity* left Rangoon, and reached Mergui on the 14th, the day before the arrival of Major Rogers and the Eastern Frontier and Burma parties, with which the Bombay party was to co-operate.

Plan of operations.

No time was lost in making the necessary disposition of the party for commencing the triangulation. The plan of operations decided on was that the Bombay party should complete the triangulation near the base-line, including its connection with the Eastern Frontier series, and any verificatory and secondary triangulation that might be requisite before taking up the necessary astronomical observations, whilst Major Rogers with the Burma parties extended the triangulation to the southwards as far as possible until the middle of January, when both parties were to assemble and proceed with the measurement of the base.

Triangulation commenced.

The signal-men were sent off to their stations by boat on the 18th of November, and a complete observing party with Troughton and Simms' two-foot theodolite No. 1 on the 19th to King's Island for the hill station of Kapa Taung, where final observations were commenced on the 24th and finished on the 27th.

Arrival of base-line apparatus.

Mr. Atkinson meanwhile having arrived with the base-line apparatus at Mergui on the 23rd, I sailed back thither to ascertain that the equipment was all right, to see it properly stowed, and to organize, instruct, and start the leveling party, all which was accomplished by the 5th of December, when I resumed the final observing at Pawo (island) station, whither the main party had been transported in the interval. I may remark here that all the travelling had to be done in open, country sailing boats, and that it was a continual source of inconvenience, delay, and anxiety, progress depending entirely on fair weather with favouring wind and tide.

Leveling party started.

Completion of the principal triangulation.

The final observations were carried on henceforward without any noteworthy occurrence until their completion, as follows:—

At Kapa Taung H. S., between 24th and 27th November 1881. (Leveling party organized and started in this interval.)

At Pawo H. S., between 5th and 7th December 1881.

At Toung pilá or west end of base-line T. S., between 9th and 11th December.

At Natlaintaung H. S., between 13th and 18th December. An azimuth was observed at Natlaintaung to a pair of circumpolar stars.

At Minthantaung H. S., between 21st and 27th December. An azimuth was observed at Minthantaung to α Ursæ Minoris (Polaris).

At Tatoung H. S., between 28th and 29th December.

At Tauribiye or east end base T. S., between 30th and 31st December. A set of circum-meridian star observations for latitude was taken on the nights of the 1st, 2nd, and 3rd January 1882 to eleven pairs of stars.

At Sandawat H. S., between 5th and 8th January. A set of circum-meridian star observations was taken at Sandawat on the nights of the 5th, 6th, and 7th January to thirteen pairs of stars.

The west end of the base-line was again visited and a set of circum-meridian star observations taken for latitude to fifteen pairs of stars, on the nights of the 10th, 11th, and 12th of January, and also a set of circumpolar star observations to α Ursæ Minoris for azimuth, between the 11th and 15th January, after which Minthantaung was revisited and circum-meridian star observations for latitude taken on the 16th, 17th, and 18th January to fourteen pairs of stars.

Finally a set of circumpolar star observations for azimuth was observed at the east end of the base-line, between 23rd and 30th January, by Major Rogers, whilst the measurement of the base-line was being begun.

The above statement includes all the observations taken with Troughton and Simms' two-foot theodolite No. 1.

Progress of the triangulation to the southward under Major Rogers.

Meanwhile Major Rogers, with the Eastern Frontier and Burma parties immediately under him, was engaged in prosecuting the triangulation to the southward of Mergui through the archipelago.

No principal stations having been prepared or definitely selected during the previous season, his first object was to lay out the series, build the stations, and clear the rays, &c. He accordingly, as soon as possible, after reaching Mergui, embarked in the *Celerity* with the whole of his establishment in tow, and, dropping parties at the stations to be built first, proceeded to reconnoitre the archipelago, laying out the series of principal triangles as he went.

With the aid of the steamers, he visited 16 islands and selected as many stations, extending the approximate series 170 miles, as far south as latitude 9° 20′, and returned to Yajeo, the first station for observing at, within a month after starting, by the 15th December.

The final observations were carried on rapidly, overtaking the building and clearing parties by the 15th January, when the usual hazy weather had begun, and all had been done that could be accomplished in the time with the means available. Seven new principal stations were built and observed at, embracing an area of 1,667 square miles, extending the series 94 miles to the southward.

Detail of Triangulation under Major Rogers.

The final observations were completed at the undermentioned stations as follows:—

With Waugh's two-foot theodolite No. 1.

At Yajeo H. S.,	between	15th	December	1881	and	18th	December 1881.
Tai-ai-pin-zouk H. S.	„	21st	„	„		22nd	„ „
Linya H. S.	„	24th	„	„		26th	„ „
Kisseraing H. S.	„	29th	„	„		31st	„ „
Alaymhán H. S.	„	3rd	January	1882		5th	January 1882.
Hsaeekyun H. S.	„	7th	„	„		8th	„ „
Kau-Yay H. S.	„	11th	„	„		12th	„ „

With 12*-inch theodolite by Troughton and Simms.*

At West Lampee H. S., between 13th January 1882 and 14th January 1882.

With 12*-inch theodolite No.* 181, *Troughton and Simms.*

At East Lampee H. S., between 14th January and 15th January 1882.

The observations at this last station were taken by Mr. L. Pocock, all the rest by Major Rogers.

A great number of observations were taken to fix the islands and hill peaks of the archipelago; many of the peaks, however, were so densely overgrown with forest as to be hardly distinguishable, but the objects fixed will be of value, as geographical points.

Assembly of entire party for the base-line.

Whilst the last series of latitude observations was still in progress, Major Rogers with the whole of his triangulating party returned from the southward to take part in the measurement of the base-line. The star observations were somewhat hurriedly brought to a

close on the 19th of January, and the whole party assembled at the east end of the base on the 22nd.

The steamer *Celerity* and the steam-launch, together with all the country boats that were not absolutely required, were now dismissed, and all the hands that could be spared were discharged and sent in the discarded boats to Moulmein.

Preparatory arrangements for the base-line.

During the month of December the base-line apparatus had been conveyed by degrees, whenever boats had been available for the purpose, to the east end of the base, where there was a landing place and the most convenient spot for encamping on. The carpenter, smith, and two or three skilled khalasies meanwhile had been well employed in putting together the trestles, tent frames, &c., &c., so that everything was just ready in good time. The ground over which the base-line runs had been marked out and roughly leveled during the previous season, but beyond clearing the side drains little or nothing could be done to it before the middle of this January, owing to its being under water or too wet to be dealt with. The work, however, was now pushed on rapidly, and no inconvenience was experienced from the delay. The measuring apparatus was put into working order, and the members instructed and practised in the manipulation of the instruments as soon as possible. The comparisons of the compensation bars with the 10-foot standard (A), those of the 6-inch microscopes with their scales and those of the runs of the micrometers of the comparing microscopes, *k* and *l*, with the standard foot ($1/f$), were taken on the 25th and 26th of January.

The measurement of the base-line.

The actual measurement of the base was commenced on the 27th and went on slowly, but steadily, in the usual manner without any mishap. The measurement proceeded from east to west, *i.e.* from right to left of the observers, who were south of the bars, facing north, the tongues of the bars pointing also in that direction.

Distribution of work.

After the second day's work, the observers and instruments were arranged as follows, and this order was maintained to the end:—

No. 1 β Major M. W. Rogers, R.E., at the boning instrument 21 feet in rear of the set of bars;

„ 2 α Lieutenant the Hon'ble M. G. Talbot, R.E., at the W. microscope on the rear end of compound bar A, origin of the set;

„ 3 A Mr. C. P. Torrens at the R. microscope on the advanced end of compound bar A.

„ 4 B „ L. J. Pocock „ S „ „ B.

„ 5 C „ R. W. Senior „ T „ „ C.

„ 6 D „ D. Atkinson „ P „ „ D.

„ 7 E „ C. D. Potter „ U „ „ E.

„ 8 H „ Lt.-Col. B. R. Branfill „ V „ „ H.
the terminus of the set.

„ 9 Moung Shoay Gyoke, with a second boning instrument, laying the trestles in advance.

No. 2 had charge of the last fixed register from the beginning of the set until he had seen it safely covered up by a register box without being touched. It was his duty also to hand the '*director*' in passing down the final alignment. The temperature of the two components of compound bar B. and of the air was registered by No. 3; Nos. 4, 5, and 6 kept up the field-book in triplicate, making all the entries independently as they were called out, set by set, by the various observers: thus, immediately after the final alignment and before the final length was passed down, whilst the advanced register was being adjusted and the three recorders (4, 5, and 6) last named were otherwise unemployed, No. 3 gave out the temperatures which he had just recorded, and No. 2, the height of the rear and advanced ends of the set above the registers, which had been entered in a note-book by himself and No. 8, who finally proclaimed the completion of the set and the particulars of the (⊙) mark defining the terminus of the set. The spare time of No. 7 was spent in looking after and correcting the length and alignment of the chain-men and trestle layers in advance. No. 8 was fully occupied in directing and aiding the approximate focus and the approximate alignment—besides the laying and observing the register at the terminus of each set.

Two days bar-comparisons taken at centre of the base.

On the 7th of February, the 9th day of the measurement, the centre of the base was reached, and the two following days were spent in comparing the compensation bars with the standard.

Completion of the measurement.

The measurement was resumed on the 10th and brought to a conclusion in 5 days (at the rate of over 28 sets per day) on the 15th of February, the 14th day of the measurement. On the 14th February 36 sets were done in 9 working hours, at the rate of a quarter of an hour per set: the quickest having occupied only 12 minutes, the slowest 19.

Rapid progress.

It is believed that this is the largest day's work ever done with the same apparatus.

The 258th set and a half fell 3·22 feet short of the (⊙) mark defining the west end of the base, which quantity was measured off on Cary's 3-foot brass scale.

Remark upon the soil.

The first (eastern) half of the base was over comparatively good firm ground, but the last (western) half was for the most part over a clayey flat that was much cracked by the heat, and very shaky. It was found necessary to fill the crevices round the registers with pure dry sand, and to place the registers in pits filled up to ground level or higher, with sand; and every precaution was taken to preserve them intact and unmoved from set to set.

Two days bar-comparisons at close of the measurement.

The 16th and 17th February were spent in a third series of bar-comparisons at the west end of the base.

Conclusion of the operations and return to Calcutta.

The triangulation and the line of levels having both been completed and arrangements made for closing and protecting the station buildings in the vicinity, and for delivering them to the local officials, the majority of the party proceeded to Mergui and took passage by the first steamer for Calcutta, where it arrived on the 7th of March.

Disposal of the instruments, &c.

The theodolites and trigonometrical instruments were returned into store in the Mathematical Instrument Department; the camp equipage was stored with that of the astronomical parties at Chinsurah; and the base-line instruments and apparatus were sent to the Great Trigonometrical Survey Office at Dehra Dun.

Entire out-turn of work.

The entire out-turn of trigonometrical work accomplished by the combined parties engaged in the work comprises 15 triangles, fixing 15 new stations, covering an area of 1,688 square miles, and extending the series 109 miles southward of the point reached the previous season, with a very considerable number of secondary (topographical and geographical) points in an area of 3,344 square miles exterior to the principal triangles.

In addition to the above, and besides the measurement of the base-line, four determinations of the astronomical azimuth were obtained near Mergui, and seven astronomical latitudes—four of the latter about Mergui and three about Moulmein.

A line of levels was executed 23 miles in length between the base-line and Mergui, where it is intended to establish an observatory for tidal investigations. In the course of this work ten permanent bench-marks were connected, four of which are trigonometrical stations.

I am glad to report that the conduct of each and all the assistants was unexceptionally good throughout.

Health of party.

The health and working capacity of the natives was on the whole very good, but a few of those who had remained at Moulmein during the preceding recess were so debilitated as to be unfit for work. Several of the Bombay men succumbed to the enervating effects of the climate and food, and have since died.

Note on the Astronomical Azimuth and Latitude Observations about the Mergui Base-line.

The astronomical observations.

Astronomical observations for the determination of the azimuth and the latitude were required at both ends of the base-line, and also at other principal stations of the series in the neighbourhood, in order to obtain a good mean value of these elements, that should be as free as possible from the disturbing effect of any abnormal local attraction upon the plumb line at any one station.

The azimuth stations.

31. The hill stations of Natlaintaung and Minthantaung were selected for the extra azimuth observations, on the north and south sides of the base-line respectively, as being apparently less likely to be affected by any irregularities of local attraction in an east or west direction than the other stations in the immediate neighbourhood.

The observation of one circum-polar star at both elongations was found to be impracticable. It was therefore intended to observe a pair of stars at their opposite elongations. Owing to cloudy and hazy weather this was also found to be impracticable after the first azimuth, and we were obliged to be content subsequently with observations to α Ursæ Minoris (Polaris) at one (the western) elongation only; taking double the usual number of observations with two observers, one of them at the telescope and the other at the levels and microscopes; this was found to be quite feasible.

Circum-meridian Latitude Observations.

Circum-meridian star observations for latitude.

Circum-meridian star observations for latitude were taken at the same stations as azimuth observations, with the exception of Natlaintaung, at which it was surmised that there might probably be an abnormal excess of local deviation of the plumb line in a northerly direction, and the principal station next to the northward, Sandawat H. S., was preferred as being less objectionably situated on that score

The principal share of these observations, as far as the setting the telescope and making the intersection of the star was undertaken by myself, and, in the case of the Minthantaung observations, I took them alone as Lieutenant Talbot was engaged on other duties, preparing the base-line, &c.

Observatory tent.

The observations were taken throughout in the ordinary observatory tent belonging to the party, the frame and top of which had been divided in two in the centre, and the halves separated so as to leave a complete meridional aperture 8 or 10 inches wide from horizon to horizon through the zenith. The junction of the two halves was made by thin cross pieces of iron at the peak of the tent frame, and at intervals down the fly. The aperture was covered by a separate strip of cloth (or *purdah*) which could be attached or removed at will, and this arrangement proved sufficiently convenient without adding appreciably to the weight or portability of the tent.

Stars used.

Forty-seven stars were selected from the Nautical Almanac and from the Greenwich seven-year Catalogue for 1864, in pairs of nearly equal north and south zenith distance ranging between 9° and 38°, and in right ascension all between 1 hour and 8 hours, so as to be suitable for observing about the meridian between sunset and one o'clock after midnight, during the month of January. My instructions were to observe ten pairs of stars on three nights each; but as I was uncertain of the value of some of the stars' places selected from the old Greenwich seven-year Catalogue, I endeavoured to secure twelve or more pairs, and succeeded in obtaining 11 pairs at the east end, 13 pairs at Sandawat, 15 pairs at west end, and 14 pairs at Minthantaung. We had no experience or previous practice, but after a little while the routine became easy and tolerably quick: it was as follows:—

Modus operandi.

The 24-inch theodolite having been adjusted during the day, was examined and leveled about sunset, when the transit of a high star was observed on the meridian, to determine the error and rate of the Sidereal chronometer. The recorder was provided with a table of the selected stars showing their aspect, altitude and zenith distance, the chronometer time of their culmination or transit, and the maximum interval therefrom, within which it was requisite to observe them, so as to avoid, if possible, the necessity of using the second term in the formula of reduction. The intention was to observe the star as near to its culmination as practicable.

Marks were made upon the circular lamp-table by which the telescope was very readily laid approximately in the meridian with either a north or south aspect, and it was then set to the altitude of the star about to be observed. A few seconds before the proper time for the first observation the telescope, set to the proper altitude, was moved in azimuth from the meridian to meet the star, and the instant of completing the intersection at the proper part of the horizontal wire of the telescope was called out by the observer and noted by the recorder, who was watching the chronometer, and who read out the time registered, which was then checked by the observer looking at the chronometer. The level was then read and recorded, and lastly, the readings of the vertical limb, either the altitude or zenith distance, directly, by means of the two vertical microscopes (G and H).

The telescope was now turned over 180° in altitude and the same in azimuth, so as to change the face of the instrument from east to west, or *vice versâ*. The telescope being again set to the zenith distance or altitude of the star on the meridian, the second observation was made as near as might be to the time of its culmination, the time, level, and vertical microscope readings being recorded. A repetition of this observation followed as quickly as possible, after which the setting of the instrument was again reversed and a repetition of the first observation taken. This completed the set of four observations to a star for the night, and the instrument was immediately set ready for the next star, barometer and thermometer readings being taken frequently in the intervals.

The even and steady illumination of the limb by the hand lamp was found to be a difficult and dilatory process, and a fixed light upon the graduations to be read was a great desideratum.

Time occupied by a set of observations.

With two observers the average time occupied in observing an entire set was nearly 5½ minutes, between a minimum of five minutes and a maximum of 7 minutes; but with only one observer, an average of 6½ (between 6 and 7 minutes) for each set.

Towards the conclusion of the night's work another transit was taken for error and rate of the clock.

After some little practice it was found easy enough to observe 30 stars with all the requisite subsidiary observations in half a night, between sunset and midnight, and if an ordinary two-foot theodolite were specially adapted for this kind of work by a more suitable level, steady illumination and other improvements, a greater number might be obtained, under ordinarily favourable circumstances, without difficulty.

Estimate of progress for one season.

I estimate that seven groups of latitude stations, one degree apart, and three stations near to one another in each group, might be observed in a season. Or if only one station were observed in a single locality, twelve latitudes might be determined extending over an arc of as many degrees of the meridian.

Collimation and index error determined.

During the observations on each night the horizontal collimation error was determined by means of a good referring-mark lamp signal, and the zero or index error of the vertical microscopes likewise.

Run of level.

The value in arc of a division of the level scales was determined by observations for the purpose, taken several times during the operations; that of the vertical axis level was found to be almost identical with the value in ordinary use, previously determined.

Barometer. The barometer readings were taken by an aneroid which was compared with a George's portable mercurial barometer at both the highest and lowest stations visited, and corrections applied accordingly. The corrected barometer readings were projected and a curve for each night drawn, whence the correct pressure corresponding to the mean time of observing each star was taken and entered in the angle book.

Thermometer. The corresponding temperature was interpolated directly from the original observations.

Refraction. From these interpolated values a mean refraction was computed for each star on each night from Bessel's refraction tables in use in the Great Trigonometrical Survey computing office.

Extract from the Narrative Report, dated 4th October 1882, *of* MAJOR M. W. ROGERS, R.E., *Deputy Superintendent, Survey of India, in charge Eastern Frontier and Burma Parties.*

I TOOK over charge at Bangalore on the 20th September, and on the 26th the party left recess quarters for Burma and reached the field head-quarters at Moulmein on the 12th October.

As it was your intention to have a base-line measured at Mergui during the season, it became necessary for me to arrange for labour, supplies, and boats, not only for my own establishment, but for that of the base-line party under Lieutenant-Colonel Branfill, which was to go direct from Calcutta to Mergui.

The rains had not ceased in Burma on my arrival there, so I had ample time to make all arrangements, and the party left for Mergui on the 12th November, arriving on the 15th.

Colonel Branfill in the Indian Government steamer *Celerity* had arrived the day before; so having handed over his men and boats to him, and arranged for the storage of the Government property, I was then ready to carry out my part of the season's programme, which was to extend the triangulation as far south as possible before the weather became too misty for observations, when it was arranged that the party should return to Mergui and aid in the measurement of the base-line.

You had obtained the Indian Government steamer *Celerity* for the use of the triangulation, and Colonel Branfill had also obtained the loan of the steam-launch *Moulmein;* in addition to these, I had two open cargo-boats and a decked schooner for the carriage of men and stores.

No stations had been selected or built in advance, so the first thing to be done was to push on this part of the work: I therefore landed Messrs. Pocock and Potter on the two islands where I proposed placing the first stations in advance, and I then proceeded in the *Celerity* to make a thorough inspection of the Mergui Archipelago with a view to selecting stations for the triangulation as far south as the end of British territories.

I visited sixteen islands during my expedition, landing on several of them at more than one place in order to find water and the best place from which to commence the ascent of the hills.

Sixteen stations were selected, extending the series from latitude 11°40′ to 9°20′, or about 170 miles. Two stations fixed upon were not visited, and two islands visited were rejected.

Having completed this part of the work, I returned to Yajeo H. S., and commenced the principal observations there on the 15th December.

During the time I was observing, the building of stations and cutting of roads were pushed on vigorously by Messrs. Pocock and Potter.

By means of heliotropes and the ordinary Morse Code, I was able to communicate with them and the steamer, and they with each other, so that we were always acquainted with the progress of each party's work, and I was able to utilize the steam power, not only for my own observing party, but to transfer the assistants and their men from one island to another, whenever they required it.

The steam-launch was most useful in taking me to several stations which the steamer could not have come near owing to the shallowness of the water, and I used her on this work whilst the *Celerity* went to Mergui for coal.

There was nothing particular to note in the observations themselves, save that on the morning of the 31st December, whilst observing at Kisseraing H. S., an earthquake occurred which, though hardly perceptible to a by-stander, was at once detected by the movement of the levels of the great theodolite and by the heliotrope (to which I happened to be observing at the moment), rising and falling in the field of the telescope.

The observations were carried on until the 15th January, when it became necessary to close work in order to reach the base-line at the time agreed on: even before this the haze, which last year had so impeded Captain Hill's observations, began to give trouble; and under any circumstances I doubt if observing could have been carried on beyond the end of the month, and as it was the recognition of intersected points was most difficult during the last ten days.

The observing season here may be said to commence on the 15th November and end on the 15th January, and even this brief time is liable to be curtailed by heavy rains at the commencement and premature setting in of the haze at the close.

It is therefore most necessary that no hindrance should occur through delays in travelling, and I can only wonder how any work at all was done in the previous season, when days were spent in drifting from station to station in open boats. Thanks, however, to the power of steam, we were able, in the very brief time we spent on the triangulation, to accomplish the following work.

Observations were taken with the 24″ theodolite at seven principal stations, and with the 12″ at two more, advancing the series 94 miles, and fixing seven new stations embracing an area of 1,667 square miles.

Seven new stations were built on the islands. To reach these stations, whose heights above the sea ranged from 500 to 1,500 feet, 23 miles of pathway had to be cut through most dense forest jungle, a portion in one case having to be made over mangrove swamps, by felling trees and making a causeway. The hill tops had to be cleared of forest, and in some cases rays had to be cut to enable the adjacent stations to be seen.

With this large amount of work to be done at each station, it was only to be expected that the observations should catch up the preliminary operations, and consequently no stations have been built in advance.

In future operations, to ensure that there may be no delay from this cause, there should be two building parties; and in addition, during the latter part of the season, when the haze prevents observing or selecting, the whole of the party should be employed in building and clearing.

The party returned to Mergui on the 18th January, and after having paid off and dismissed such men and boats as were no longer required, it was moved to the base-line and placed at the disposal of Lieutenant-Colonel Branfill for the measurement.

During the measurement, arrangements were made for covering and protecting all the stations of the series, which was done; and although no stations, save those on the Mergui island, could be placed under official protection, the inaccessibility and deserted nature of the country is such that I do not consider the stations to be in any danger except from natural causes. After the completion of the base-line the party left for Moulmein, where they arrived on the 25th February.

I then received your instructions to observe astronomical latitudes at Moulmein, and I therefore selected three stations of the triangulation near Moulmein and proceeded to observe for latitude at the first of them—Moulmein H.S.

As I foresaw that owing to my tidal inspection work I could not arrange to observe at all the stations myself, I carefully instructed Messrs. Pocock and Potter in the use of the 24″ theodolite and the method of observing circum-meridian altitudes, and also in all the necessary computations for selecting suitable pairs, &c., and worked with them for two nights, until I was satisfied that they might be trusted alone. They observed for latitude at Martaban H.S. and Toung-zun H.S., whilst I left Moulmein for Rangoon and Port Blair.

On completion of the latitudes the party left Moulmein for Mussoorie, under the charge of Mr. Potter; Mr. Pocock having been ordered to join the Mysore party at Bangalore.

I received every assistance in his power from Captain Butler, Deputy Commissioner of Mergui.

Captain Hotham of the Indian Navy and the officers of the Indian Government steamer *Celerity* did everything in their power to aid me in my work, and to their cordial co-operation I am greatly indebted for the good progress which I made in my observations.

The triangulation this year was entirely on the islands of the Mergui Archipelago.

The islands may all be described as high and precipitous, the smaller ones rising sheer out of the sea, the larger ones having steep valleys between their various peaks, but no flat ground of any extent.

Towards the north, the islands are fringed with a belt of mangroves, some two or three miles in width, the only access to the mainland being up the larger creeks at high tide (the tide here rises from 16 to 18 feet). Such as this is the large island of Kisseraing and the eastern side of Domel: wherever there is a small valley with fresh water there are nearly sure to be mangroves at its mouth.

The islands south of 11°20′ have stretches of fine sandy beach, and in many cases good water coming out of the hills and flowing over the sand into the sea.

In Davis Island, latitude 9°50′, there is almost a small river coming down from the hills with a fine waterfall, and in the interior of Kisseraing another was found. The peaks on many of the islands are of a considerable height, many being over 1,000 feet and several over 2,000.

With no exception, the islands are covered with dense forest, with thick undergrowth and creepers in every direction, a thorny kind of cane being one of the most common. This makes it very difficult to penetrate to any distance, as every step of the way has to be cut through the undergrowth.

The soil is very rich, consisting chiefly of leaf mould, and it remains moist all the year round, as it receives an immense amount of rain, and the thick foliage prevents the sun penetrating during the hot weather.

The density of the forest may account for the few beasts and birds which are seen. Monkeys are plentiful, coming down to the beach at every low tide to catch crabs and shell-fish in the mud.

I saw tracks of wild pig, deer or tapir, leopards or some animal of that description, and on Forbes' Island, what seemed to be the footsteps of a rhinoceros.

Jungle fowl, imperial pigeon, curlew, horn-bills, king-fishers, and on Davis Island one pair of snipe, were the only birds I saw; but it must be remembered that I have only penetrated, at the most, half a mile into any of the islands except along the paths out to the stations.

The trees are in many cases very large and high, having a great length of trunk without any branches, apparently devoting all their strength to reaching the upper air and sun-light as soon as possible. One tree, which had been blown down on the island of Kisseraing, measured 116 feet from the ground to the beginning of branches, and 227 feet in all.

Fish are very plentiful, and during the cold weather there are many temporary fishing villages established on the northern islands by men from Mergui and around, who dry the fish for export to Rangoon.

Turtle are met with on most of the islands, but all I saw of them were the remains of two very fine ones, which had served overnight as the meal of some of the wild men of the islands.

The archipelago is uninhabited save by the fishermen above mentioned and the roving tribes of Selungs or sea-gypsies mentioned by Captain Hill in his last report. Of these I met several, and as a rule found them by no means averse to communication, rowing up to the steamer or steam-launch and getting on board the latter when asked. These were in the southern islands, where they mostly live. The only ones I saw on the northern islands fled in such haste that they left most of their boats and property behind.

At Lord Loughborough's Island, in latitude 10°25', they took us to their temporary village, where we were received by the whole community in a very friendly way. The village was on the beach, just above high tide, and under the shade of the trees; it consisted of a few platforms of light wood floored with split bamboos and roofed with the leaves of the nipa palm.

The men were as a rule a fine set, and extremely ugly, not at all like the Burmese; the women were small and also ugly. They were all dressed decently, but not superabundantly, and many of the men wore necklaces of glass beads.

They had a little rice and paddy, and a large quantity of evilly smelling shell fish and sea slugs drying in the sun. These latter they collect for sale, and also a large shell, which takes a beautiful polish and sells at Mergui for Rs. 8 per 100. It is used in England, I believe, for button-making.

Their boats are very light and fast; the lower portion is a single tree, the sides being heightened by bamboos or some kind of fibrous palm, which are woven in and out on uprights, projecting from the two upper edges of the boat.

Their oars are beautifully made, and they use them with great skill, making their boats fly through the water. They have also masts and a sail of palm leaves. They are very clever in weaving mats, bags, &c., but I could hardly get any, as when I visited them it was not the mat-making season, which is the monsoon, when they can do but little fishing. They have some fine dogs, which they employ in hunting the wild pig in the islands, the weapons they use being the ordinary hog-spear.

There was a Malay trader living at the village I visited, who traded with them for their shells, &c., giving them cloth, rice, and beads. He said that he came from Penang; he had a house a little larger than the rest, in which, besides his stock in trade, were such out-of-place articles as a violin and a bottle of lavender water.

A few of the Selungs speak a little Burmese, and thus we were enabled to talk to them and get a few of their words, which I give below spelt phonetically:—

Sea ..	.. Okol.
Shell ..	.. Keniyak.
Boat ..	.. Káking.
Tree ..	.. Káyá.
Mountain	.. Delai.
Rice ..	.. Pêleo.
Oyster.	.. Geetap.
Fresh water	.. Oyem.
Village	.. Alainplam.
Paddy	.. Pay.
Malay	.. Ba-tak.
Dog ..	.. Oyee.
Coral ..	.. Kalong.

At present there is no communication between Mergui and any of the islands, none being necessary, as they are nearly uninhabited and produce nothing. The coasting steamer from Rangoon to Penang passes through a portion of them in going between Mergui and Maleywoon or Renoung.

I visited this latter place, which is on the Siamese side of the mouth of the Pakchan river, and may become a place of importance if the canal through the isthmus of Krau is ever carried out. At present it is a prosperous village, inhabited entirely by Chinese with Malay coolies, and owned by a so-called Rája, who is a fine looking Chinaman, holding the mines under the Siamese Government. The mines, which produce rich tin ore, in appearance like dark gravel, are a few miles off; the smelting works are close to the village and the Raja's house, which is a fine one of the Indo-English style. The smelting is carried on in rather

primitive fashion; the blast is produced by huge bellows like a syringe, with a man working the piston-rod forward and back.

The Chinese seem to be well-to-do, and have good gardens. The day I was there was their mail day, the coasting steamer from Penang communicating with China having just arrived, and many households seemed to have received a box from China, which they were opening in front of their doors with great pleasure and excitement.

Extract from the Narrative Report of MAJOR CHARLES STRAHAN, R.E., *Deputy Superintendent, Survey of India, in charge No. 1 Topographical Party, Gwalior and Central India Survey.—Season* 1881-82.

Description of country triangulated.

THE following description of the country under triangulation I have compiled from notes furnished me by Mr. Doran. As already stated, it comprised three standard sheets between the parallels of 24°15′ and 25°0′ north latitude and the meridians of 72°30′ to 73°0′ east longitude. From the north-east corner of this portion of country, and not far from the small cantonment of Erinpura, rises a range of hills known as Sarnau, which runs about south-south-west for 20 miles, and rises up to a maximum height of 2,773 feet at Makrora H. S. near its southern extremity. Below the western face of this range, some 12 miles from its northern end, lies the town of Sirohee, the capital of the State of the same name. Here there is a branch post-office, a dâk bungalow, and another bungalow used occasionally by the political officers. At the foot of the southern extremity of the Sarnau range flows from west to east a branch of the Chota or Western Banas, and separates that range from Mount Abu. This mountain extends in a south-westerly direction for another 19 miles, the culminating point, known as Guru Sikkar, being 5,650 feet above the sea; about 5 miles south-west of Guru Sikkar is the small sanitarium of Abu. In continuation of the Abu range, but only connected by a very low watershed, is the Jairaj mountain, the highest point of which is 3,575 feet, and the length about 12 or 14 miles. Beyond Jairaj, again, but bending more to the westward, is the Lakha mountain, which is not more than 5 miles long, and is only 1,946 feet high. This brings us to very nearly the south-western corner of the country under description, so that this chain of mountains, of which Guru Sikkar is about the centre and the culminating point, divides the ground diagonally into two portions. More or less along the meridian of 72°30′ or the western limit lie the Nadona and Dohirra hills. The highest point of this last range is known as Sunda, and is 3,252 feet in height.

The triangular space (about 700 square miles in area) included between these hills is low, and more or less covered with jungle; but dotted about it are small hills 200 or 300 feet above the general level. The general drainage is from the centre: one stream, rising in the northern slopes of Abu, flows north-north-west; whilst another, rising from the same part of the country, flows south-west and out between the Lakha and Nadona hills. They are both called the Sukri, which merely implies that the river dries up. This name seems to be so commonly given to river courses hereabout that it ceases to distinguish one river from another, and is very apt to lead to confusion. A made road runs through this valley in a south-westerly direction from Erinpura *viâ* Sirohee to Deesa. Immediately below the Abu, Jairaj, and Lakha mountains on the opposite side, *i.e.* to the south-east, is the Western Banas valley, down which runs the Rájputána State Railway from Ajmere to Ahmedabad; its course is, roughly speaking, parallel to the river on its left bank. To the south-east, again, of this valley are rugged masses of hills inhabited by Bhils and Girassias, some of whom proved to be decidedly hostile and much averse to allowing Mr. Doran even to enter their pals. The highest point is that known as Mard, which is 3,080 feet.

General level of the country.

The general level of the Banas valley may be taken at 1,050 near Rohera in the north-east, and 630 where the river leaves the work. This shows a fall of 420 feet in a little over 40 miles, or just about 10 feet per mile. To the west of the Abu ranges the height of the centre of the valley is 1,020 feet, and 25 miles to the south-west of that is 710 feet, giving 12 feet per mile, or much the same slope. To the north and north-west the fall appears to be about 15 or 16 feet per mile. These values must not be taken as strictly accurate, but are sufficiently so to give a general idea of the fall of the ground. The Western Banas was the only river bed in which there was any running water, and even this disappeared before it left the ground under description.

Cultivation.

Of cultivation there is not much anywhere; the best part is along the course of the Banas river, but even here there is no great extent of cultivated country, whilst on the other side of Abu by far the greater part of the land is covered with brushwood and grass. No doubt, parts of it may be poor, stony soil, and in other parts there may be a lack of water, but the real reason of the scarcity of cultivation is the unsettled state of the country and lawless character of the inhabitants. When reconnoitring with Mr. Doran we passed over large tracts of land in Sirohee which in my opinion only required clearing and tilling to produce excellent crops, but which are now densely covered with bush-jungle. Water was not outwardly visible, it is true, but there was no reason to suppose that there would be any lack of it if wells were sunk, more particularly near the beds of the streams. As you approach Palanpur cultivation increases, and very good rice is grown, more particularly at a small village called Palkhari, which is noted for the excellence of its rice, known as kamod.

Places of note.

The largest native town met with was Sirohee, already mentioned as lying at the foot of the western slopes of the Sarnau range. Although the capital of a State and the residence of a Rájá, it is but a small and uninteresting town. The sanitarium and small cantonment of Abu is situated on the top of the mountain of that name, as also are the celebrated temples of Dilwara and the small temple of Guru Sikkar, which occupies the extreme summit of the mountain. The Dilwara temples are nearly 1½ miles north-east of the residency; these temples are very far from imposing from the outside, but the interior is beautifully carved, more particularly the inside of some of the domes, which are the best of their kind that I have ever seen. All the plateaux of Mount Abu have been already surveyed on the 6-inch scale by Major G. Strahan, and in his report of 1870-71 he gives a short account of the sanitarium and the places of interest to be found there. Since that date another road to the top has been made up the eastern side of the hill; it connects the Rájputána-Malwa Railway with the cantonment. The distance is 15 miles, and the total ascent is 3,000 feet, nearly all of which is surmounted in about 9 miles, the first three and the last three miles being comparatively level. In the valley to the south of Mount Abu are numerous ruins, the remains of Chandal Nagri or Chandrawati, which is said to have been a very large and populous city. Mr. Doran reports that all over the valleys in that neighbourhood he met with ruins indicating that at one time this part of the country must have been far more prosperous than it is now. To the south-east, again, of Chandrawati are the five temples of Ámbá Málá on the road to Dántá. Of these, only one is kept up, and the others are left to crumble away; it is dedicated to Ámbá Diváni and is noted far and wide, pilgrims going to it daily in considerable numbers to make their offerings; the revenue derived from this source, after deducting the expenses connected with the temple itself and its priests, goes to the Rao of Dántá. A mile or so to the south-east of the Ámbá temple is the small village of Kumária, occupying the site of what was once a large and flourishing town called Kandalpur. The following tradition was related to Mr. Doran by the priest in charge of the temple. During the reign of Rája Bhimak, who resided at Kandalpur and was noted for his virtues, Ámbá Devi descended on the earth. She selected Bhimal Sáj, mahajan, one of the numerous good and religious men then living in the country, as her *protegé*, and on him she poured down wealth, enabling him to double his charities and to build temples. He built 360 holy places, and his fame was at its height when the goddess condescended to converse with him personally. She spoke thus to him—"Tell me, my son, to whose assistance and constant care do you owe your present good name and prosperity, for your reputation is world-wide on account of your munificent charities and the numerous temples you have erected." His answer was "To Gorji" (a Jain god). Thrice did she ask him the same question, and thrice did the ungrateful man make the same answer. Enraged at his ingratitude, the goddess cursed him and decreed that all the temples should be burned to the ground. The destruction of the temples at once commenced. Bhimal Sáj, seeing this, fell at her feet and begged that in consideration of his charity and the numerous temples built by him his good deeds should not be buried in oblivion, but that his name might be handed down to posterity. The goddess, taking compassion on him, ordained that five out of the 360 temples should be spared; the remains of the others are still to be seen all round about. In reality I believe the Mohamadans are responsible for their destruction.

States in which the work fell.

The country under description belonged to the three states of Sirohee, Pálanpur, and Dántá, of which Sirohee occupied about three-fourths, the remainder being nearly equally divided between the other two.

Country plane-tabled.

Part of the ground surveyed in detail was extremely easy, and part very difficult; the whole of standard sheet 85 was bad and was undertaken by Messrs. Kitchen and Tate and sub-surveyor Abdul Gufar, assisted by Mr. Doran for a few days. Of this standard sheet the eastern portion is a high plateau, averaging about 2,600 feet above the sea; it forms the highest part of the extreme western edge of the great Rájputána and Central India plateau. From this, again, rise the highest ranges and peaks of the Aravalli mountains with the exception of Mount Abu, which overtops them by no less than 1,000 feet. Unlike Abu, they are mere ridges or peaks. This high country is open, undulating, and fairly covered with villages: there is a good deal of cultivation, but from the nature of the ground it runs in long lines following the small valleys, almost every one of which is, where practicable, dammed up at intervals, forming a series of steps on which rice is grown. Where the valleys are wide and the slopes of the hills can be cultivated, wheat is sown. The inhabitants are Brahmins and Rajputs, principally the former; a few Bhils may be found in the outskirts of each village, but there are no Bhil páls at all. It forms part of the watershed of India; for from the north and to the east flow the sources of the Banas, which eventually flows into the Ganges; to the south are the sources of the Sábarmati, which flows into the Gulf of Cambay, whilst to the north-west rise two or three branches of the Luni river, which loses itself in the Rann of Cutch. The fall from this plateau to the west is abrupt, the first three miles of the Goria Sembal pass taking you down 1,200 feet. After that the slope is gradual, but the road is difficult, from jungle and rocks, for another eight miles, after which the open country is reached. The scenery is rather fine all along this western limit of the Aravalli, the mountains throwing out bold spurs towards the plains, forming a most intricate piece of country covered with heavy jungle. When once clear of the belt of forest below, nothing is visible but a great open plain with isolated hills or short ranges of hills rising abruptly from it. As you go north-west these hills become fewer, and in 50 or 60 miles you

may say you are in the desert. Due west there are more hills, some of them reaching an elevation of about 1,500 feet above the plains, or even more; but they only form comparatively small groups, and in no way seriously interfere with a traveller's progress abou the country. At the same time they are somewhat more troublesome to the surveyor, for they are most awkward hills to climb and to get about on; and as the heat of the sun is always great, and after January rapidly increases until in the end of March it becomes scorching, it is no slight task scrambling over the big rocks of which these hills are composed. There never being shade for the tents, makes it very trying even under their shelter. On the 12th March I registered a maximum in my tent, 99°, on the 21st it was 103°, and on the 25th it reached 107°, and did not go below 100° till past 5 in the afternoon. After that I marched towards the hills, where I found it really quite pleasant compared to what I had left. The change from the burning heat and glare from the sand without a drop of water to the narrow valleys with small streams trickling between green trees was very striking. By the 3rd April I was very nearly on the plateau, and at 5 P.M. the thermometer was only 78°, whilst at 6 A.M. of the 4th the thermometer on the grass read only 45°. This was, however, in an exceptionally cool place, at the bottom of a narrow valley just below the plateau and close to a running stream.

Forts, towns, &c.

The fort of Jalor fell into the season's work; it may be called a first class fort from its size and position, but I cannot give any detailed account of it, as no one is allowed to enter it. It is situated on a high hill standing 1,200 feet above the plain at the north-west end, and 1,500 towards the south-east end of it. On the north, east, and south the hill rises abruptly from a sandy plain; the city, which is enclosed by a wall, lying at the foot of the hill to the north. At a distance of 3,000 yards to the west is the Roza hill, which rises 320 feet above the highest point in the fort, and commands nearly all the interior. It is, however, a difficult hill to get up, and the top is nothing but a mass of huge rocks, piled one on top of the other. From here I got an extremely good view of the whole position, and was enabled to make a tolerably complete sketch on the one-inch scale for the standard sheet. I could also see enough to show me that it was not kept in repair, and it had all the appearance of being perfectly deserted. I observed some half dozen guns on the bastions, but not a sepoy nor a living soul was to be seen anywhere. The Roza hill is connected by a small range with the north-western portion of the fort hill, but there is a good pass for animals, though impassable for carts, through it.

Extract from the Narrative Report of Major T. T. CARTER, R.E., *Deputy Superintendent, Survey of India, in charge No. 2 Topographical Party, Khandesh and Bombay Native States Survey.—Season* 1881-82.

Description of country triangulated.

THE country triangulated consists of certain outlying villages in Khandesh and Nasik, lying in the Aurangabad district of the Nizam's dominions, extending over an area of about 500 square miles, lying between latitudes $\frac{20^\circ-0'}{20-18}$ North and longitudes $\frac{74^\circ 52'}{75\ 20}$ East. This ground lies to the south of the Satmala range of hills, above the Gháts, and at an average height of 1,900 feet above the level of the sea. The northern portion is hilly, the hills being covered with heavy jungle. To the east and south the country is more undulating, but is still woody; while to the west and south-west the country is tolerably open, having a few trees just round the villages.

Description of country plane-tabled.—Sheet No. 21.

This sheet consists of three low ranges of hills—one to the west, one very nearly in the centre, and one to the east of the sheet. They run in a north and south direction, and naturally form two valleys. The one to the west is drained by the Bori river, which runs direct into the Tapti; the one to the east is drained by the Anjani, a smaller river, which enters the Girna, a tributary of the Tapti. Both these valleys are very fertile and well wooded with fine mango topes. The Bori river, which enters this sheet at an elevation above sea level of 850 feet, falls to a height of 650 feet, where it leaves the sheet; the hills on either side rising gradually to a height of about 250 feet above the level of the rivers. The eastern range rises to about the same height above the valley of the Anjani, but the character of the range is different, the summits of the hills forming considerable plateaux, on the top of one of which is built a temple and *paka* tank called Padmala, by which name the range is known. All the hills in this sheet are covered with low scrub and grass, but no heavy jungle: consequently the country is much cut up with ravines and small streams, the tracing of which on the ground is always a tedious work to the detail surveyors. A portion of the Chálisgaon and Páchora talukas consists nearly entirely of the valley of the Girna river, running through the sheet from south-west to north-east, with its tributaries, the Titur, Hinra, and Bohla, which take their rise at the foot of the Satmala hills. The north-west corner of the sheet is hilly, the ground rising to an elevation of close on 1,300 feet above the level of the sea. A portion of this ground consists of the Jawardi reserve forest, of 5,000 acres. The Khandesh Government farm at Rokra, of about 1,250 acres, enters the sheets. It is chiefly a cattle farm with breeding stock. There is no very heavy forest in this sheet, the Jawardi reserve forest being newly planted out. The hills to the west are covered with grass and scrub jungle, while the valley of Girna is open and well cultivated, and, except the

Sheet 23.

western quarter of the sheet, is studded with fine mango topes. At the village of Jamdha a *paka* masonry dam is thrown across the river, and is the head work of two small canals, one of which is taken north of the river and is 25 miles in length, and the other, south of the river, is about 10 miles in length. The sheet is much cut up by numerous small *nalas* and ravines. The boundary between the Khandesh and the Nizam's territory extends along the southern portion of this sheet, and the detail survey has been carried into the Nizam's country for a distance of 1½ miles. The Great Indian Peninsula Railway passes through the sheet from east to west.

Sheet No. 24.

Sheet No. 24 comprises 142 square miles of the Chálisgaon taluka, with an overlap of 50 square miles into the Nizam's territory. This country lies immediately below and north of the Satmala hills, which here rise up abruptly some 1,800 feet above the level of the plain country, which is about 1,150 feet above the sea. The country immediately below the Ghâts, at the foot of the hills, is rugged and raviny, and covered with low scrub; but the mountain sides facing the north are, comparatively speaking, bare. On reaching the top of the Ghâts (Nizam's territory) the country is fairly level, with a gentle fall to the south, and is well covered with fine forest trees. A portion of the Patna reserve forest enters into this sheet, but the forest is not very densely wooded. The rest of the country towards the north is open, very fertile, and studded with fine mango topes, and is well watered by the Titur, Utaoli, Bakra, and Garad nalas, tributaries of the Girna river. These become considerable streams during the monsoons; their banks are steep and they retain their water all the year round. The Great Indian Peninsula Railway passes through the north-west corner of the sheet.

Sheet No. 34.

The country plane-tabled this year in sheet No. 34 comprises part of the Nandurbar taluka. About half of this sheet had been completed during the field seasons 1878–80, leaving the western portion of the sheet and one plane-table (64 south-east) at the south-east corner to be completed. The country in plane-table 64 south-east is hilly. The hills (rising to a height of about 950 feet above the level of the sea) consist of narrow ridges of trap running in a north-east and south-east direction, and here and there intersecting each other The hills are bare, and the country is well adapted for plane-tabling. Mr. Graham says "a remarkable feature in these ridges is that every alternate ridge is very stony, the tops being scattered over with huge boulders." The western portion of the sheet is of a different nature: the ground is more undulating, and for the most part covered with thick forest; the inhabitants are chiefly Bhils, who have made considerable clearings in the forest; the country is very unhealthy, the only time in the year when it is safe to work being from the beginning of April to the beginning of June, and even in these months fever is very prevalent. Part of the Deomogra reserve forest (about 33 square miles) enters into plane-tables 65 north-west and south-west of this sheet. Fortunately, most of the forest trees are deciduous, otherwise the whole of this tract would have been very difficult to survey. There is generally an undergrowth of tall grass, which adds to the surveyors' difficulties A few wild beasts inhabit the Deomogra forest and the other forest tracts on the banks of the Tapti. Mr. George, while surveying the Deomogra forest, killed a she-bear and her two cubs. She had been the terror of the Bhils in those parts, having mauled no less than 13 men, killing 5 out of the number. Mr. George had some difficulty in getting men to enter the forest, so he thought the best thing he could do was to bag the bear first.

Towns—Sheet 21.—Parola.

Parola, $\frac{\text{Lat. } 20° 53'}{\text{Long. } 75° 10'}$, population 13,294, the head-quarters of the Mahalkari, is a large straggling municipal town It gives its name to the peta of Parola, a subdivision of the Amalner taluka. The chief object of interest is the fort, built 150 years ago by Jaghirdar Hari Sadashir Damodar. It is built of stone and mortar, is about 525 feet long by 435 feet broad, and surrounded by a ditch. The fort was dismantled in 1857: nothing now remains except the walls. There are several fine stone Hindu temples inside the town, and outside, several old mosques. The chief trade is in "lugdas" (women's robes) and in cattle, cotton, and grain. The town contains a Mahalkari's court, three schools, a post-office, and a dispensary.

Erandol.

Erandol, $\frac{\text{Lat. } 20° 55'}{\text{Long. } 75° 22'}$, a municipal town, head-quarters of the Erandol subdivision; population 11,295. It rises with high battlemented walls from the bank of the Anjani river, and is connected by metalled roads with Dharangaon, Parola, and Mhasawad railway-station. It was ravaged by Shivaji in 1630. It has a considerable trade in cotton, indigo, and grain, and has a manufactory, where a coarse kind of paper is made. It has a Mamlutdar's court, a large school-house, dispensary, and post-office. In the Pandao Vada (a ruined stone mansion) there is some beautiful and varied scroll work.

Bahadurpur.

Bahadurpur, Amalner taluka, $\frac{\text{Lat. } 20° 58'}{\text{Long. } 75° 5'}$, population 3,586, built in 1596 by Bahadar-khan, was pillaged by Sambhaji in 1685. At that time it was a place of much importance, with many bankers and merchants. It is now a squalid place of no particular note. There are the remains of the old fort.

Tamaswari.

Tamaswari, in peta Parola, Amalner taluka, $\frac{\text{Lat. } 20° 47'}{\text{Long. } 75° 5'}$, population 858. It is situated on the Bori river, and has the remains of a handsome temple built 125 years back.

Páchora, Lat. 20° 40′, Long. 75° 24′, population 3,682, the head-quarters of the Páchora taluka. I stands on the railway 35 miles south-east of Dhulia and 231 from Bombay, and is the nearest station to the Ajanta caves, distant 25 miles. There are the traces of a wall and old fort. Páchora contains a Mamlutdar's court, travellers' bungalow, post-office, and school.

Sheet No. 23.—Páchora.

Bhadgaon, Lat. 20° 40′, Long. 75° 16′, population 6,152, a municipal town, the head-quarters of the Bhadgaon peta of the Páchora taluka. The town is built on an island formed by two branches of the Girna river. The towns, battlements, and four main gates of what was once a strong town wall, remain. Inside the wall some of the buildings are said to be 400 years old. Its trade chiefly consists in cotton, indigo, linseed, &c. It contains a Mahalkari's court, school, post-office, and dispensary. The Khandesh Government farm, the only Government farm in the Bombay presidency, lies two miles to the north of Bhadgaon.

Bhadgaon.

Bahal, Chalisgaon taluka, Lat. 20° 26′, Long. 75° 5′, population 1,848, a large village situated on the Girna river. It has the remains of an old *paka* fort and some old temples on the rising ground, showing that at one time it was a place of importance.

Bahal.

Kajgaon, Páchora taluka. At the railway-station, half a mile north-west of the village, are two cotton-presses—the New Indian Press Company and Messrs. Hormarjee Brothers.

Kajgaon.

Nagardeola, Lat. 20° 34′, Long. 75° 15′, population 4,416. A large village about five miles east of Kajgaon railway-station. There is a ruined Hamadpanti temple of Mahadeo to the west of the village.

Nagardeola.

Chalisgaon, Lat. 20° 27′, Long. 75° 8′, population 5,603, the chief town of the Chálisgaon taluka, stands on the Great Indian Peninsula Railway, 34 miles south of Dhulia. The old fort has fallen into complete decay. It is a place of no great importance, except that it lies on the main road to Kanad, in the Nizam's territory, *viâ* the Outram Ghât. The town is situated on the left bank of the Titur river. The Mamlutdar's court and post-office lie between the river and the railway-station, which is on the right bank of the river and distant about half a mile north-west of the town. Within the town is a school, where English and the vernacular are taught.

Sheet No. 24.—Chalisgaon.

Ranala, Lat. 20° 21′, Long. 74° 56′, population 3,030, is situated in the Nandurbar taluka. It is next in size and importance to the town of Nandurbar. It is an *inami* or alienated village. The first inamdar is said to have been a grandson of the Mahratta Shivaji. It was once the seat of an independent chief ruling over the greater part of Western Khandesh, and in A.D. 1750 was said to have had a population of 20,000 people. There is a large settlement of Bohoras at Ranala, who keep up two schools for their children. The town contains over 200 *paka* houses. In addition to the abovementioned schools, there is a vernacular school and a school connected with the Scotch mission.

Sheet No. 34.—Ranala.

Forts.

Of forts, properly so called, there are none, though there still remain the old walls round the towns of Parola, Erandol, and Bhadgaon. At Bahadurpur, Bahal, Pachora, Chálisgaon, and Narainpur (sheet No. 34), there are remains of what were at one time Keeps, consisting of four walls with round towers at their corners.

Hills and passes.—Outram Ghât.

The Satmala range is crossed at the Outram (more generally known by the name of the Ranjangaon) Ghât. A well laid out metalled road of about five miles in length, which was opened in 1872, leading from the foot of the hills on the British side to Kanad, the chief town of the Kanad taluka, Dowlatabad Circar of His Highness the Nizam's territory and the outlying British villages, is taken to the top of the ghât. The road is practicable for traffic of all descriptions.

Gortalao Ghât.

Farther east there is a disused pass called the Gortalao Ghât, leading from the village of Wagli in British territory *viâ* Saigowhan to Kanad. It is now impracticable for any one but a man on foot.

Sheet No. 21.—Padmala Hills.

Padmala hills, three miles east of Erandol. Abrupt hills with flat tops or plateaux covered with grass and scrub.

Sheet No. 34.

Two small passes, leading from the large village of Ranala, in the valley of the Amrawati, crossing a narrow ridge of hills that separate it from the Tapti valley, and leading to the large village of Koparli. At present they are impracticable for laden carts, but with a little labour might be made serviceable and of much use as short cuts between the villages mentioned.

Principal roads.—Sheet No. 21.

(1) Metalled road with masonry bridges and mile-stones leading from Dhulia *viâ* Parola and Erandol to Mhasawad railway-station.

(2) Metalled road 22 miles in length from Parola to Kajgaon railway-station, on the Great Indian Peninsula Railway, with masonry bridges and mile-stones. Nine miles of this road enter this sheet.

(3) Metalled road, Erandol to Dharangaon, masonry bridges and mile-stones. It branches off about one mile east of Erandol from the main road to Dhulia.

(4) Road from Erandol to Maheji railway-station, metalled between the village of Maheji and the railway-station. In course of being metalled throughout.

(1) Metalled road from Pachora to Bhadgaon, with mile-stones; length 8 miles. It continues past the Government farm at Rokra to Talwara, but the latter portion is unmetalled.

Sheet No. 23.

(2) Thirteen miles of the metalled road from Parola to Kajgaon-railway station previously mentioned.

(3) A laid out, but unmetalled, though partially bridged, road from Pachora *vid* Kajgaon and Waghli to Chalisgaon, and ultimately Nandgaon to Nasik Collectorate.

Sheet No. 24.

(1) Metalled road from Dhulia to Chálisgaon, and thence to Kanad, crossing the Outram Ghât.

(2) Unmetalled road from Pachora *vid* Chálisgaon to Nandgaon, Nasik, in continuation of sheet No. 23.

Sheet No. 34.

Main road from Dhulia *vid* Songir, Dondaicha, and Ranala, to Nandurbar. The portion entering this sheet is unmetalled, but it is proposed to metal it throughout between Dhulia and Nandurbar. This road continues *vid* Visarwari and Navapur to Surat, and is much used.

Railway.

The Great Indian Peninsula Railway enters at its 201st mile from Bombay, crosses through the north-west corner of sheet No. 24, through the whole of sheet No. 23 in a north-easterly direction, and through the north-east corner of sheet No. 21, which it leaves at the 248th mile from Bombay.

Rivers.

The Tapti (sheet No. 24), and its tributaries the Girna and Bori (sheets 23 and 24), the Amrawati, Shivnad, and Nasu (sheet No. 34), are the principal rivers met with in this year's work. The Girna and Bori take their rise in the Sahyadri mountain range in the Nasik district; the Shivnad, Nasu, and Amrawati, in the low hills in the Nandurbar taluka.

Tapti.

The Tapti in sheet No. 34 runs through a country of thick forest, inhabited by wild beasts, and, except for small clusters of Bhil huts, with no sign of inhabitants.

The Tapti is neither used for watering fields nor for boat traffic.

Girna.

The Girna, in Khandesh, flows through a well-cultivated valley. At the village of Bahal (sheet No. 23) the Jamdha canals stretch east about 27 miles on the left and 12 on the right bank.

Bori.

The Bori river and its tributaries are much used for irrigation. Neither the Girna nor Bori are navigable, and in the dry season there is little water left in their beds.

Inhabitants.

In the talukas of Khandesh, viz., Amalner, Erandol, Chálisgaon, and Pachora, which are comprised in sheets 21, 23, and 24, the population is chiefly Hindu, being in a proportion of nine to one of the Mahomedan population.

The Hindu population is chiefly composed of cultivators, comprising Kunbis, Bhils, Banjaras, and Kolis, in the proportion, roughly speaking, of 5, 1, ½, ½ out of a unit of population of 10, the remaining 3 being composed 1 of Mussulmans and 2 of Hindus of other castes and trades. In the Nandurbar taluka the Bhil population came first in number in proportion of 3 Bhils to 1 Kunbi. The Banjaras are in the same proportion as in the other talukas. There are very few Kolis; but their place seems to be taken by a caste of cultivators called Konkanis. The Hindu population is about the same in proportion to the Mahomedan as in the other talukas, viz. 9 to 1.

Kunbis.

Of the people above mentioned, the Kunbis are supposed to have settled in Khandesh about the eleventh century, being forced to leave Guzerat by the encroachment of the Rajput tribes. They are hard-working and most skilful husbandmen. Some of them are well to do, but most are poor.

Bhils.

The Bhils come next in number. In the talukas of Amalner, Erandol, Chálisgaon, and Pachora they are for the most part in service as labourers with Kunbis and other cultivators, or work fields on a joint system, where the landowner provides the land and grain, the Bhils the labour. In the Nandurbar taluka the Bhils are of a less civilized stamp; they form the greater part of the population. The landholders are chiefly Gujar capitalists, and the Bhils are content to work for their food, a little clothing, and liquor distilled from the flowers of the mowa tree (*Bassia longifolia*).

Banjaras.

The Banjaras may be divided into those who keep to their old trade of carriers and those who have begun to settle as husbandmen. They are strong, well-made, and as a rule good-looking, both men and women; but they are by no means clean. Since cart-roads have been opened and they have to compete with railways, they have had to give up to a great extent their wandering ways. There are several divisions of the tribes. The largest is that of the Charan Banjaras, who form about one-half of the whole Banjara population. The Banjara settlements are usually distinguished from those of the Kunbis, or ordinary cultivators, by each family having a distinct hut as a dwelling place.

Kolis.

Kolis are either fishermen or village labourers. They are the same caste as what are called "coolies" in the north-west. In point of numbers they come next to the Banjaras.

Konkanis, chiefly in the Nandurbar taluka, are sometimes confounded with the Bhils.

Konkanis.

Their ancestors are supposed to have come from the Konkan, or low country immediately below the Ghâts. They are cultivators.

Amalner taluka.

Soil, products, &c.—The soil is either black, brown, or red; the former is a rich loam, the second coarse and gravelly, and the red an alluvial clay. Bajri, jowari, pulse (kulith), a small quantity of wheat. There is a considerable cotton cultivation, equal to about one-half of the cereal crop.

Erandol taluka.

Soil, products, &c.—Except in some very poor tracts near the hills south-east, the soil is the same as in Amalner. The chief crops are jowari, bajri, wheat (a little), pulses (chiefly gram), and a cotton cultivation, equal to about one-third of the cereal.

Pachora taluka.

Soil and products.—Good black soil in the valley of the Girna; in other parts a red clay soil, which near the hills is light and friable. The chief crops are jowari and bajri, and a small quantity of wheat and oil-seeds. A considerable quantity of *til* is grown, and the cotton cultivation is nearly two-thirds of the cereal.

Châlisgaon taluka.

Soil and products.—The soil is not so good as in the other talukas mentioned; much of it to the south being hard and stony, and the black soil of the Girna valley rests on a subsoil of gravel and sheet rock: consequently bajri is the chief cereal crop, nearly double that of the jowari. Very little wheat is grown, but a larger quantity of oil-seed (til). The cotton cultivation is about one-third of the cereal.

Nandurbar taluka.

Soil and products.—The prevailing soil is a rich black loam. Crops: bajri, jowari, rice, and a considerable quantity of wheat, are grown. Of pulses, gram is the largest crop. There is not much cotton grown, the cotton cultivation being about one-twelfth of the cereal.

Irrigation works.

Jamdha canal.—The Jamdha canal (sheet No. 23), left branch 27 miles long, right branch 12 miles long. The works consist of a masonry weir across the Girna river at the village of Jamdha. Both canals are completely bridged and regulated, and command an area of about 45,000 acres for irrigation.

Mhaswa lake.

The Mhaswa lake, 2¾ miles east of Paróla (sheet No. 21), about 4 miles in circumference, but the water-supply varies very much. During the season under review there was very little water in it, but a considerable extent of marsh. The water is retained by a mud and a stone dam 500 yards long. Two small canals are taken out, commanding an arable area of about 4,000 acres.

Wells.

Over most of the country water is found from within 20 to 40 feet of the surface, and the country is well studded with irrigation wells.

Antiquarian remains, objects of interest, &c.

At Diggi village (sheet No. 23), 8 miles south-west of Kajgaon railway-station, on the right bank of the Garad nadi, there is an old but small Jain temple in very good preservation, probably some 600 years old. There are some well-carved figures inside the building, representing a party of dancing-girls and their attendant musicians.

At Patna (deserted village), sheet No. 24, at the foot of the Satmala range and 10 miles south-east of Châlisgaon, there are some Brahmin caves, dating probably from the twelfth century, and of interest as being probably one of the oldest settlements in Khandesh.

Extract from the Narrative Report of MAJOR J. R. WILMER, S.C., *Deputy Superintendent, Survey of India, in charge No. 5 Topographical Party, Rájputána and Malwa Survey.—Season* 1881-82.

Country triangulated.

THE country triangulated consisted chiefly of hills and undulating and intricate country, easy enough to throw points over, but tedious and troublesome for plane-tablers. The greater portion of it consisted of the bed of the Máhi river after it takes its peculiar bend near the village of Anant. From flowing almost due north at this place the river sweeps suddenly round and flows south-west into the Gulf of Cambay. The triangulation extended chiefly over the Bánswára, Dongarpur, and Udepur territories.

Country plane-tabled.

The country plane-tabled was adjacent to that triangulated, and the nature of the ground very much the same, there being only 190 square miles of open country out of 1,092 square miles surveyed, the remainder consisting of hilly, jungly, and intricate ground, being chiefly below the Ghát and amongst the feeders as well as the bed of the Máhi river.

Towns.

There were two towns surveyed this season on the large scale—Jaora and Bánswára. The former is well known, and is the residence of the Nawab of Jaora, a chief who takes much interest in the welfare of his estate The city is kept generally very clean, and is in this respect a contrast to some other large cities. It is situated in flat, open country; a high wall with bastions runs three-fourths round. Opium is grown on almost every inch of ground. Bánswára, on the contrary, is a dirty, ill-kept, half-deserted, overgrown village, the residence of a Rájput Rájá. The town is situated on a spur and at the foot of some high hills.

These hills are to its south-east, and completely overlook the place. There is an attempt at fortifications in the shape of a high wall running nearly all round the city; but the wall was never intended to resist artillery, being only a protection against the Bhils with their bows and arrows. The city to the north being on a slope is completely commanded from some high, open ground to the north. The country round about is remarkable for its numerous small lakes, Bánswára itself having six within a radius of a mile, and another large and deep one some two miles due east. A building built on its banks is the Rájá's summer residence.

Roads.

There were no roads of importance in this year's work; in some parts even carts were not to be got owing to there being no roads along which they could go.

Rivers.

The Máhi was the only river of importance, a considerable portion of which runs through the work. This river is much broader now; its bed continues to be very rocky and shingly. It is not passable during the rains, but can be crossed almost anywhere after the rains and before the monsoons. There are a few fords and no ferries. The principal passes across the river are between Nain and Bajrangarh, Seogarh and Bájna, Bájna and Kelgaj, Kelgaj and Khandu. This last road crosses the Máhi river three times.

Inhabitants.

The inhabitants are chiefly Bhils. Their manners and customs have been fully described in the *Rajputana Gazette* and the reports of other survey parties. I mentioned in a previous report the peculiar custom of the Bhils of branding their male children on the arms above the wrist with burning cotton dipped in oil. This leaves a permanent mark for life, and the Bhil proper is to be recognized by this mark. The children are branded at about the age of seven, or when they get their first permanent tooth. I have not seen this custom mentioned in the *Gazette* referred to above, nor in any previous survey report, nor in the general annual report of surveys; and as it is a principal custom, and was not known to officers in the Bhil corps or Political Agents with whom I came in contact, I have alluded to it again.

Products.

On the upper plateau opium is most extensively grown, being the chief product of the country. The usual fields of corn are cultivated, but are of very small importance compared with the opium cultivation. Below the ghâts, amongst the bhils, rice and Indian corn are mostly cultivated, though not in very large quantities, sometimes barely enough for their own consumption, except in parts of Dongarpur, but this has not come under survey yet. The cultivation of opium is gradually being introduced, but the Bhil is not willing to give up his old ways of living, and it is not until they realize the profits of opium cultivation that they take to it with any faith or zeal. The nature of the country is against opium cultivation to any great extent, but it grows well on either side of rivers and low flat ground.

Extract from the Narrative Report of Brevet Lieutenant-Colonel R. G. Woodthorpe, R.E., *Officiating Deputy Superintendent, Survey of India, in charge No.* 6 *Topographical Party, Khasi and Garo Hills Survey.—Season* 1881-82.

The country to be surveyed consisted of the lower spurs of the Tipperah Hills running northwards past the boundary into the plains of South Sylhet, as well as some isolated hilly country due south of the station of Sylhet lying between Fenchugunj and the Manu river and a portion of Hill Tipperah, the whole lying west of and being a continuation of last year's work.

Triangulation.

Very little triangulation was necessary, as several stations of the Great Trigonometrical Survey and others previously fixed by this party fell in the different portions of the country to be surveyed, affording sufficient points to start work from. A small amount of subsidiary triangulation was done, but the exigencies of superintending the new sub-surveyor's work prevented my carrying on any triangulation in advance of the plane-tabling.

Work of Assistants.

Major Badgely did not, I believe, mention Mr. Ogle in his report on the Manipur-Burmah survey, and in this report I have also unintentionally omitted his name I find, as it did not occur in connection with the field work under my own immediate supervision. His work in Manipur, I have reason to believe, is exceedingly good; and I hear that he availed himself, with his usual energy and enterprise, of every opportunity after Major Badgely left of extending our knowledge of that country. He has been associated with me in many different and dangerous undertakings, and has always so fully justified the confidence placed in him by all with whom he served, that I am exceedingly sorry to find he has not been as fortunate as he deserves, and has had no promotion for almost ten years. I should be very glad indeed to see his long and meritorious service speedily rewarded.

Mr. Chennell, to whom the survey of Hill Tipperah on the 1-inch scale fell, completed it by the end of March, and managed to survey 222 square miles. He secured the services of a large number of Kuki and Tipperah coolies, who were of great use to him. I was unable to visit the hills in which he was working, but I have every confidence in him, and have no reason to question the accuracy of his work.

Mr. McCay surveyed an area of 50 square miles on the scale of the rest of the work, viz. 2 inches=1 mile, and finished it by the 23rd February, when I sent him to assist Mr. Ewing, who, being entirely new to the work, found himself occasionally in difficulties. Mr. McCay's work seemed to me to be very well done; but he unfortunately, in one or two places, took as his boundary the revenue survey line, and left the western side of some low spurs untouched, somewhat spoiling the look of the fair map This defect will be remedied. Mr. Keating did 31 square miles, which, as far as I could test it, seemed accurate. His work will be still further tested this season. Mr. Campbell had some difficult country to do, but turned out 41 square miles of very good work. Mr. A. Ewing had never done any survey work before, and the country in which he found himself set down is such as to try the resources of the most accomplished surveyor. It is therefore not to be wondered at that his progress was slow, but he surveyed 21 square miles with very fair accuracy.

Shah Nasiruddin turned out 31 square miles of very good work.

Description of country, &c.

The country surveyed on the 2-inch scale presents few actual physical difficulties, inasmuch as it is easy to chain up the several streams which flow with an almost level course from the low hills in which they take their rise to the plains. In the part worked by Messrs. Keating and Ewing and the sub-surveyors this was the case, except in a few places where the swampy nature of the valley made it impossible to chain along the banks of the stream, or even to distinguish its course, which frequently loses itself in the marsh. As a rule, the centre line in these blocks of hills is the watershed, and the streams flow thence nearly due east and west. The highest hills in these tracts are not much more than 100 feet above the plains; and as the streams descend in the first hundred yards of their course some 50 or 60 feet, it follows that, for the four miles, which is the average distance they have to traverse before reaching the plains, their fall is only 12 feet in a mile, which just keeps the water flowing. These streams are only 3 or 4 inches deep (except here and there, where shallow pools occur) during the cold weather, but in March, after a heavy shower, they rapidly become impassable. On one occasion, when traversing one of these streams, I found myself at noon only a mile from the tea-garden Chaotali, at which my camp was pitched, and as the planter had asked me to breakfast at 12½, if I found myself near enough, I left my men in a small out-garden to rest and await my return, and went on. A good road runs from this out-garden to Chaotali, being crossed several times by the stream, which here has cut a deep and narrow channel for itself through the sandy soil; but I had no difficulty in wading across the stream, without getting any water into my boots. While at breakfast, one of the very heavy storms of thunder and rain, so prevalent in the latter half of March, came on, and sheets of water fell till 4 P.M.; when the storm passed away the sun came out, and I sallied forth on a pony hoping to finish my traverse before nightfall. On arriving at the first crossing I found a swollen torrent laden with boughs of trees, grass torn up by the roots, and other debris, sweeping past, and men and women gathered on either bank unable to cross. They told me if I tried to cross on my pony I should be swept away, and they were evidently right. Fortunately I had an elephant with me, and sending for him I crossed and went on, the river (for such it then was) having risen at least five feet in the three hours. At the crossing nearest to the out-garden I found my men trying to pass over; one or two had managed it at the imminent risk of being carried down and entangled among the bamboos and creepers lining the banks and hanging into the water. There would have been no chance of getting the instruments across. The elephant had to make two journeys at every crossing, and it was 7 o'clock before we had reached Chaotali, only three quarters of a mile from our starting point.

The difficulty caused by rising streams was not, of course, experienced till March, and although the sharp turns and winding courses of all these small streams, as they thread their way between the low but steep-sided hillocks, prevent traverse along them being carried on with anything like rapidity, yet the real difficulty of these surveys lies in the fact of the low hills being all of one general average height, and all densely clad with forest and close bamboo jungle. What looks a prominent hill from the eastern plains is seen to be entirely hidden by another equally prominent hill from the western plains. On this account many of the triangulated points in these ranges are of no use in extending the triangulations, but are very serviceable in affording checks to the plane-table traverses, though it is always a work of time and trouble to find them, as at a distance of a few yards only in that jungle the most conspicuous marks in the most conspicuous trees are not always visible to the upturned eye, searching in vain to catch a glimpse of the shining bamboo basket through the tangled lacework of the beautiful leafy canopy overhead. Platforms were built in trees at heights varying from 60 to 90 feet from the ground; but although the view obtained from such "coigns of vantage" over the expanse of hills and forest was extensive, it was seldom instructive, as the indications of the general run of the streams are of the slightest, and the gentle dips between the waves of the unbroken sea of pale green bamboo or dark tree foliage below might indicate a small dry ravine merely, or the course of a large stream, and it is impossible without actual exploration to say which. Hence very little actual plane-tabling could be done; and the method generally adopted was to traverse all the principal streams and their affluents, and cut lines between, connecting the different streams in such directions as seemed to afford the best opportunities for ascertaining the general topographical features, and, where opportunities offered, platforms were constructed on lofty trees, from which a plane-table fixing could be obtained as a check on the work.

The scenery in South Sylhet is exceedingly beautiful, and especially lovely in the evening light. Here is one scene which is only a type of many such. At 4 o'clock in the afternoon I am standing on a cleared hill just above a large tea-garden. The air is beautifully soft and balmy, and looking to the east I see below me the gentle undulations and flat ground under tea cultivation, the rich dark green bushes standing out in bold contrast on the red brown soil. Among the bushes the busy coolies are at work, the women adding brightness to the scene with their brilliantly coloured robes. In the midst of the cultivation, on the banks of a clear stream in a small well kept enclosure with a pretty tank, stands the Manager's bungalow, a large, commodious house with white-washed walls and lofty thatched roof slightly hidden by tall plantain-trees. Rose bushes and other shrubs flourish in the garden, in which from my elevated standpoint I can see that the useful is not overlooked in the culture of the beautiful, as testified by a corner where many tempting looking vegetables are growing. With the orange glow of the afternoon sun upon it, the bungalow with its garden looks, as indeed I find it, a very haven of rest, comfort, and hospitality. I hear voices behind the bungalow near some large neat tea-houses, and looking in that direction I see an excellent tennis court, where an exciting contest is being carried on between the young planters of this and a neighbouring garden. Beyond the tea, the view due south is closed by the virgin forest of dark trees and feathery bamboos, the greater portion of which will soon, by the enterprise of the planters and the extension of the tea-gardens, disappear. To the south-west and west the eye wanders over the plains of South Sylhet, bounded on the south by the jungle clad hills of Tipperah, purple now and indistinct. The flat green fields, above which, as the sun sinks, soft mist wreaths float, are broken up by frequent clumps of mighty bamboos or fine old banian-trees, amid whose dark recesses a few glimpses of reddish roofs and the light blue smoke curling upwards denote the presence of villages. Beyond these, to the west and north, lie open expanses of what at this season is dry, or at the worst only damp ground, but which a few of the March and April storms will speedily convert into swamps and even lakes ("haor" in the vernacular). A thin dark line appearing here and there marks the course of a river, its waters very low now and hidden by the high banks, above which the masts of country boats and the smoke from the funnel of a steamer, just about to anchor for the night, are visible. Far away to the north, beyond the plains, the trees, the villages, and the station of Sylhet itself, rises the long, level outline of the Khasia hills faintly glowing in the sunset. A hum of voices ascends from the villages below, cows wend their way homeward through the deepening gloom, and, as the sun sinks in the brown obscurity of the distant horizon, I shut up my theodolite, and running down the hillside soon find myself at the bungalow, where a hearty welcome and an excellent dinner await me.

And here I should like to take occasion to acknowledge the very great kindness, hospitality, and assistance I and my party have always received from the planters in carrying on our work in their gardens or the adjacent country—kindness which has extended to our kalassies and coolies, who have frequently had a dry, warm shelter found for them when the inclemency of the weather rendered life in tents unpleasant.

Some good roads are being made in South Sylhet, and I hope they will be finished this year—one from Sylhet to Fenchuganj and south to Langla being very much wanted. A narrow riding road, raised a few feet from the fields adjoining it on either side, already exists between Fenchuganj and Langla, and is being improved and extended across the Manu river down to a large garden called Shamshanagar. A road is much to be desired between Companyganj and Sylhet. At present the Government road exists only in the imagination, though tall bamboos stuck in the ground at intervals are supposed to guide the traveller along it. It runs through fields, and when I passed down last December the *dhan* had just been cut, and was lying on the ground quite covering the (at all times) rather obscure path. In many places the villagers through whose fields the path passed had removed the bamboos to their neighbours' fields, and I was only aware that I was going wrong by some infuriated villager rushing at me,—

> "He cried, he roared, he storm'd, he tore his hair,
> "'Death, hell and furies! what dost thou do there?'"

Then I found that the deceitful bamboo had taken me half a mile out of my way. A bright thought struck me—"follow the telegraph line;" but this landed me in a swamp, and I only got right again after a couple of miles' detour. Most of the other so-called Government roads are merely tracks across the fields and open country marked out by bamboo stakes, a little scraping here and there through the low mud partitions between the fields showing how wide the road will be in the millenium. In December, January, and part of February a ride across the fields is not unpleasant, after that the dried-up earth cracks under the powerful sun, in all directions, making walking unpleasant and riding almost dangerous; while in the end of March, and onwards till the rains, the traveller ploughs his painful way, knee-deep, through the mud flats, over which a little later on he can gaily take his way in boats. There is a hill road across the Harargaj range leading from Sagurnat to Hingajia, which is passable in the dry weather, but ascends and descends so steeply in many places as to be difficult for laden animals, and I should think so slippery after rain as to be dangerous even for foot-passengers. The paths through the lower ranges generally follow the course of the streams, which, as I mentioned before, are very level, the only rise being one of a few feet at the watershed. In the rains these roads are impassable. In some places, as between Indanagar, Indessa, Ita, and Kijildara, the planters are opening out communications and making good roads for themselves.

The only rivers actually under survey last season were the Manu and its affluent the Deo, for that portion of their course through the Tipperah hills which fell in Mr. Chennell's work. I had received two very nice little subtense theodolites from the Mathematical Instrument Department, Calcutta, one of which I found very useful and accurate in running check traverses through and round the sub-surveyor's work. The other enabled Mr. Chennell to traverse the Manu and Deo rivers in boats with greater rapidity and accuracy than he had been able to attain the year before by cane measurements from boats.

The hills in the Tipperah territory immediately bordering on South Sylhet are not inhabited to any great extent, but within our territory all the ranges are being taken up and opened out for tea by various companies or individuals, and the words "low hills covered with impenetrable jungle" may soon be left out altogether from the maps; for the jungle, far from being impenetrable, will in a great measure have ceased to exist.

The plains in South Sylhet are very fertile and populous, and we never had any difficulty in getting our supplies at any of the many numerous bazars which are so frequently held in that part of the country.

Extract from the Narrative Report of G. A. McGILL, Esq., *Surveyor, Survey of India, in charge No. 7 Topographical Party, Rájputána and Simla Survey.—Season* 1881-82.

Description.

DEGREE sheet XX, surveyed during the season 1881-82, is unquestionably the finest bit of country that this party has had to survey for the past five years. It is quite different from the usual run of the degree sheets of Rájputána, being more or less fertile, with clumps of rocky hills of from 200 to 400 feet above the ground and extensive plains of a hard soil composed of clay mixed with sand, besides the usual rolling sand hills and ridges of the desert. The eastern half of it may fairly be called the land of Goshen, the western being arid sand-wastes, with few villages and little or no water.

Water.

There is no doubt that from the great experience acquired by a Surveyor he is well able to surmount great difficulties; but the one great difficulty which at times quite bewilders him is the making of arrangements for drinking-water for himself, his camp followers, and baggage camels. In the north-east section of this degree sheet, although water is plentiful, it has to be got with great difficulty. The country depends on its supply of water on wells which are very far apart, some villages having no wells at all and are dependent on other villages for water.

Wells.

These wells contain delicious cool water and are of extreme depth, the average being 270 feet; but one measured by me at the village of Bhakri in lat. 26° 54′ 4″, long. 72° 38′ 41″, was found to be 480 feet deep. The water is drawn up from this well by a relay of bullocks and camels. I have endeavoured to get every information I could about these wells from the villagers. They have all been dug by the charity of some rich mahajan or bania; they are well built, throughout of stone, and have one or two large cisterns on either side, round each of which runs a stone trough for the cattle to drink out of, and this is the only water that they can get, as for five months in the year the tanks are quite dry. I was told that after a depth of three "pursas" (18 feet) the sand ceases, and a coarse kind of sandstone is reached, which is easy of penetration; but at a great depth hard rock is encountered, which is blasted through till the remaining portion sounds hollow. The labourers then carefully tap through this, when a jet of liquid mud rises of an offensive smell. The work is now over, and the workmen are pulled up. The well then fills fast with water, and all that is necessary is to draw away a quantity of it, and the result is a spring of water that never fails.

It often so happens that a bucket falls in; men then are sent down seated on stout leather ropes, to which a cross-pole is fixed; they take down with them hooks for dredging the water and bring up the lost bucket. These people have told me that in some cases the hard rock that had been tapped has fallen in, and that the water below was in motion as if it were a flowing stream, and in all such cases the bucket is never found, as it is carried away: they also say that the depth of water is seldom over 12 to 14 feet. The measurement taken by me to determine the depth of the well was to the surface of the water. The wells are not broad, only 8 to 10 feet across and circular, and during the middle of the day the water is seen below like a six-inch mirror.

To form an idea of the depth of the well it may be illustrated that its depth is 120 feet more than the height of St. Paul's at London, 12 feet more than twice the height of the "Kutub" at Delhi, and 6 feet less than three times the height of the Taj at Agra.

Height St. Paul's	... ...	360 ft.
,, Kutub	... ...	234 ,,
,, Taj	... ...	162 ,,

Lakes.

On the north-west corner of this degree occur extensive plains of hard ground and fields of red sandstone, and here I came upon several dried-up salt lakes. Before the Inland Customs Department put a stop to the manufacture of salt, the Tehsildar of Phalodi used to farm out the lakes to the "Kharwals," and large quantities of salt used to be manufactured. This was before 1877, when I triangulated the country, and at which time the lakes were perfectly dry. This year, owing to the heavy rains, all the lakes had water; the larger of them is 7·1 square miles, and the smallest 2·4 square miles in area.

Sand hills.

The largest portion of this degree, lying to the south-west, is an extensive sea of rolling sand ridges of a uniform height of 100 feet. Strange as it may seem, the people of the country prefer to cultivate crops in this sort of ground; and with a good monsoon, rich crops of bajra, mót, and til are produced.

Fruits.

The fruit of the country is the matira, a luscious sort of water-melon, the seed of which is said to have been imported from Kabul. It grows almost wild, and is the great mainstay of the people and the cattle, who make use of it as food as well as to quench their thirst.

Produce.

The produce of the country depends upon the season's rainfall. Bajra, mót, and til grow well, and wheat in small quantities is raised where the ground is favourable. Melted butter (ghee) is also exported.

Manners and customs.

The population is partially agricultural and nomadic, the latter preponderating. Large flocks of sheep, goats, and herds of cattle and camels are raised. The oxen are short, but seem to be particularly strong. It is surprising to see a yoke of them dragging a heavy cart laden with large "gharas" of water over heavy sand and across country covered with low sand ridges. The cattle, owing to the scarcity, are only given water once in three days, and for the same reason the habits of the people are exceedingly dirty. The men and women of Rájputána are, I think, the most unsavoury creatures I have ever seen, even dirtier than the Thibetian coolies employed on road-making at Simla. All the people smoke, and men, women, and children are, without exception, opium-eaters.

Forest.

As may be expected, the country has no forests, but large tracts are especially reserved for the growth of timber for house-building. The larger kind of trees, are, bair (*Zizyphus jujuba*), babul (*Acacia Arabica*), and khejra, also of the accacia kind. These reserves are cared for, and trees yielding timber of 12 feet in length by 8 square inches are obtained. But owing to the plentiful supply of slabs of sandstone, the thakurs and mahajans build their houses entirely of stone.

Manufacture.

Salt used to be plentifully manufactured until it was put a stop to by the Inland Customs Department. Woollen serges of different qualities are also made, but are not exported. The rude village loom is employed in making them, and it is surprising to see how good a material is produced, almost equal to military serge. Coarse felt is also made, and is chiefly used for padding camel saddles.

Climate.

The climate is particularly fresh and healthy from 15th November to February; nothing better could be desired; a cool refreshing breeze blows all through the twenty-four hours. During these months rude health is enjoyed by every one. During the night it is bitterly cold, and water gets frozen inside the tent. With February a decided and sudden change comes on: the thermometer rises every day; and in March sandstorms are very common. The misery experienced during this time can only be described by one who has had experience of it. The sand penetrates everything, including eyes, nostrils, and ears. The box of clothing, and even a strong iron despatch-box, is not proof against its penetrating power, and as a consequence there is no partaking of a meal as long as it lasts, as everything cooked grates under the teeth and makes the blood curdle. My experience of Rájputána only extends up to the end of April; but I would presume the heat must increase greatly later on, and life must feel a burden to him who has to remain there. The salt people, with whom I spoke on this subject, and who live in a *paka* house at Agar, told me they have experienced the sandstorms for days, and that it was impossible to keep their *khas-khas* tatties wet for any time, the lake water thrown on them turning into fine salt from the intense heat of the wind.

Degree sheet XIX.

Degree sheet XIX was also partially surveyed during this season, and the triangulation extended through it, and also degree sheet XVIII. These two degrees are sparsely inhabited, XVIII being almost if not a howling wilderness. Sheet XIX contains parts of Jodhpore, Bickaneer, and Jeysulmere. A line drawn connecting $\frac{\text{Lat. } 28°\cdot0'}{\text{Long. } 72°\cdot45'}$ with $\frac{\text{Lat. } 27°\cdot0'}{\text{Long. } 72°\cdot30'}$ will divide the sheet into two parts; the eastern representing the sand, and the western the hard soil consisting of sand and clay. Water is very scarce in the whole of this degree, and especially so in the northern half, which is also very sparsely inhabited.

Towns.

The only two large towns are Phalodi of Jodhpore and Báp of Joysulmere; the former has a *paka* walled enclosure called a fort; it is a place of importance and a tehsil, and water is plentiful. Báp is also a tehsil, but in appearance it is little better than a village; there is a fine tank of water at this place.

Phalodi	Lat. 27° 8′ 0″. Long. 72° 24′ 14″.
Báp	Lat. 27° 22′ 30″. Long. 72° 23′ 40″.

Agar Salt Lake.

Between both these places, 12 miles north of Phalodi and 6 miles south of Báp, is the dry salt lake of Agar. This place has now been selected and made into a depôt of the Inland Salt Customs, and is officially known as Phalodi salt source. There is a large lake here, about 25 square miles in area; it is generally dry, but during a heavy monsoon contains water to the end of May. The salt is made by evaporation of water in large pans; the water is drawn from

wells which are sunk in the bed of the lake. The water is reached at 8 feet below the surface; it is exceedingly salt, and readily evaporates and forms into salt in the pans.

Degree sheet XVIII.

Degree sheet XVIII might well be called a "terra incognita;" it is the worst bit of desert ground I have seen. It is almost devoid of villages, and water is exceedingly scarce: very frequently a well of water only occurs in 270 square miles. In this degree I frequently came upon wells yielding poisonous water; it is very very cautiously used by the people, and only taken after a good meal, and even then most sparingly. If freely drunk it acts as a violent emetic and aperient, and frequently causes death.

Tánkás or reservoirs.

Cattle are watered from it but sparingly, and only once in three days. In some villages the rain-water is carefully collected and preserved. This is done by sinking a cistern in the centre of a funnel-shaped enclosure of some hundred yards in circumference; the rain-water rushes down the slope and collects in the cistern. These cisterns are covered over and jealously guarded; they have a door on top of the covering, which is kept closed and locked. I was told that a man or animal poisoned with poisonous water, if early taken in hand and given a free draught of this rain water, always recovers. These cisterns or wells are called by the people "tánkás," and, as might be expected, are much valued by the people of the country; and it is not till they are coerced by the vakil that their existence is made known. The water in them is clear and deliciously cool and fresh.

Sport.

Although Rájputána is in many places a perfect desert, sport in some form or other is plentiful. The Chikara, a small species of deer, is very common. They are to be met with in numbers, more especially in the grounds belonging to the Bishnoies, where they are as tame as goats. This is the only large game of the country; but bustard, both the giant and small species, as well as florican, can be shot. Partridges and grouse are plentiful. The blue pigeon and the peacock are more or less domestic birds, as they are worshipped by the people; and although the sandy plains can't afford anything of the picturesque to a desert village, still the large numbers of these birds, especially the peacock with its gay plumage and flowing tail of gold and azure, lend a cheerful aspect to these otherwise uninviting habitations.

Religion and caste.

Rájputána, like most parts of India, has a mixture of the various forms of religious persuasions. I was most struck, however, with the Bishnoies, a class of people who live by themselves and are seldom to be found in the same village with the other castes. These people hold sacred everything, animate and inanimate, carrying this belief so far that they never even cut down a green tree; they also do all in their power to prevent others from doing the same, and this is why they live apart from other people, so as not to witness the taking of life. The Bishnoies, unlike the rest of the inhabitants, strictly avoid drink, smoking and eating opium; this being prohibited to them by their religion. They are also stringently enjoined to monogamy and to the performance of regular ablutions daily. Under all these circumstances, and, as may be expected, the Bishnoies are a well-to-do community, but are abhorred by the other people, especially as by their domestic and frugal habits they soon get rich and are the owners of the best lands in the country.

Extract from the Narrative Report of MAJOR H. R. THUILLIER, R.E., *Deputy Superintendent, Survey of India, in charge No.* 8 *Topographical Party, Mysore Survey.—Season* 1881-82.

Remarks on the country.

THE country topographically surveyed this season may be conveniently divided into two classes, each of which has distinctive features. That in sheets 2, 19, 23, and 24 in the Shimoga and Kadur districts, executed by the European assistants, comprises an area of 1,460 square miles, and is of a similar character to that previously surveyed in the Malnád, consisting of forest-clad mountains and valleys presenting alternations of varied and charming scenery, but dense forests shut in the view and render the survey of these parts not only difficult, but slow; plane-table intersections from surrounding fixed points cannot be obtained, and work has to be done almost entirely by traversing with the chain. The twin rivers Tunga and Bhadra run through sheets 23 and 24, and meet at the northern edge of sheet 23, from which point they become a united stream called the Tungabhadra; and the Sharavati river flows in a north-westerly direction through sheet 2 till it reaches the ghâts, where it precipitates itself down the celebrated Falls of Gersoppa, the largest of which descends in an unbroken column to the depth of 830 feet. The Bába Budan mountains, the loftiest range in Mysore, skirt the southern edge of sheet 24, and rise like a gigantic wall to a height of some 4,000 feet above the general level of the country to the north; the summits are clear, but their slopes and water-courses are thickly covered with valuable forests, giving shelter in parts to coffee cultivation. With the exception of a small portion of open country about Shimoga in sheet 23, and around Tarikere in sheet 24, the whole of this area is covered with dense forest and jungle. The difficulties and delays which arise in surveying such country have been previously described, and it is only necessary to add that the obstacles met with in the sheets above alluded to were as great as those experienced in former seasons, and that the same care and patience have been bestowed in overcoming them. Sheets 10, 11, 14, 15 in the Chitaldroog district, and 30 in the Hassan district, comprising an area of 2,766 square miles, are in the Maidan division or open country. This portion of the Chitaldroog district is almost throughout

a barren and dry land. It is included in the valley of the Vedavati or Hagari, which during the hot months is for the most part dry. The general level of the ground is about 2,000 feet above the sea. It consists of great undulating plains, traversed by a belt, about 20 miles broad, of approximately parallel chains of hills, mostly bare and rocky, the highest point being 3,863 feet above sea level. Trees are few in number, and the low ground, where not cleared for cultivation, is covered with stones and a dwarf species of mimosa. Water is scarce, and the climate, as compared with other parts of Mysore, is drier and hotter. The greater part of this area was executed by the sub-surveyors, and is for the most part open and easy, where the plane-table was utilized to its best advantage, and the chain hardly ever needed.

General remarks.

The programme arranged for the season's operations proved to be somewhat more than could be got through, and sheet 2 had to be left incomplete. Nevertheless a larger out-turn was completed than had yet been accomplished, and this with a reduced European staff. The success of the season's operations was in a great measure attributable to the good health of the surveyors, who were able to work uninterruptedly throughout, and also to the energy they displayed in taking every advantage of it. The whole of the work has been carefully examined, and that executed by the European assistants has stood the tests remarkably well, and was found to be accurately and carefully surveyed. The plane-tables done by the sub-surveyors were also found accurate as far as the position of the details was concerned, and with two or three exceptions the general direction of the lines showing the configuration of the ground was found fairly correct, but the drawing of some of them is still crude. The general tendency with natives is to exaggerate the features of the low ground, and on this account I took special precaution to have a large number of well determined heights taken in a systematic way with a theodolite, over their work. In the five sheets which were chiefly executed by them in the open and undulating ground, 1,061 heights were observed, giving an average of one height to every 2·8 square miles. By the aid of these extra heights, in addition to those fixed trigonometrically, the draughtsmen found no difficulty in modifying the drawing in the fair maps. All the surveyors were furnished with the clinometers designed by Major G. Strahan, and observed heights therewith throughout their work. But the results are more or less unsatisfactory, especially in the ground where the variations of height are small, and having such a large number of theodolite heights there was no necessity to utilize them. I have endeavoured to adhere to 50 feet vertical intervals for the contour lines as far as feasible throughout the whole of the season's mapping, and to follow out, as far as the nature of the ground would allow, the method of keeping the contours closer to the streams, as introduced by Major Strahan last year in sheets 27 and 29.

Extract from the Narrative Report of MAJOR T. H. HOLDICH, R.E., *Deputy Superintendent, Survey of India, in charge Kohat Topographical Party—Season* 1881-82.

Plan of detail.—Survey operations.

THE plan of operations for the party (with the exception of Mr. McNair) was simply to resume plane-tabling from the line to which it had been completed the previous year, the starting points of the various plane-tablers being all more or less contiguous to the western boundary of the Kohat district forming the line of our north-west frontier, and the general direction of the work from west to east. Mr. McNair formed no exception to the rule as far as his plane-tabling was concerned, but he had in the first place to fix extra points by triangulation over an area of about 500 square miles, and in addition to extend a reconnaissance across the frontier wherever opportunity offered.

Party breaking ground in the field, &c.

In order to gain a little time, Mr. McNair left Dehra for the field in advance of the rest of the party, at the end of November. Mr. Claudius (who took charge in the absence of the Deputy Superintendent) followed with the party about the 12th December; and the plane-tablers were at work by the end of December, commencing on dates varying between the 23rd and 30th. As the field season closed about the 16th April, its actual length was thus reduced to a very short four months.

Run of triangulation and arrangements.

Mr. McNair's triangulation consisted in fixing a few secondary stations on points in the neighbourhood of Bahadur Khel, and intersecting sufficient natural objects to give him the basis for his plane-tabling and to determine a sufficiency of heights. The most important point he reached was the celebrated Kafir Kot peak, an account of which will be found appended. On joining the party on the 4th February, I proceeded to the north-east corner of the district, and there fixed a few secondary stations, which were sufficient, with the addition of such great trigonometrical stations as existed, to secure the triangulation of that (the only untriangulated) part of the district. Subsequent to inspecting and checking the topographical work of the party, I triangulated for the Kohat City and Cantonment plan, which, with reduction of supplementary heights, and other computations, occupied the rest of the season.

Triangulation completed.

The total area traingulated was about 500 miles by myself (independent of the city triangulation) and 500 by Mr. McNair, or 1,000 in all. The secondary triangulation of the district executed

by Lieutenant Walker 30 years ago was quite sufficiently well marked to enable the triangulators to intersect a sufficient number of points from these stations to serve the purposes of topography. No previous reconnaissance was necessary, and no time or money was wasted in the erection of poles or points to intersect. The natural features of the country were abundant, and as the class of instrument used was no higher than the 6-inch theodolite, they were sufficiently definite for the purpose. Of course, the linear errors are large—larger than they would have been had the instruments been perfect of their sort, but not too large to affect the results as the basis of topography on the one-inch scale.

Remarks on the country triangulated.

The country triangulated to the north between Khushalgarh and Attock is remarkable for nothing but its general roughness. It is fairly open and free from anything like heavy jungle. The Jawaki and Peshawar district hills close it in on the west with a long, continuous, rugged line of peaks, running to an altitude of between 4,000 and 5,000 feet. On the east the river Indus forms the boundary between the Kohat and Rawalpindi districts. The river between Attock and Khushalgarh is always picturesque, and often grand in scenery. It flows between steep rocky banks formed by bands of many-coloured limestone fringed with patches of deep white sand. There is not much vegetation—a few scattered tamarisk-trees, and an occasional grove of stunted olives, are generally all that can be seen from the river banks; but here and there a patch of cultivation slopes down to the river and modifies its excessive wildness. A spur from the Jawaki hills, called Nilabgash, extends eastward to the river, and is the only obstacle to a fairly level line between Attock and Khushalgarh. A road exists already, running nearly parallel to the river, without which this portion of the Kohat district would be difficult to traverse, from its extreme roughness. It all belongs to the Khattak section of the Pathan tribes. The country triangulated by Mr. McNair consisted chiefly of the flat, open, sandy district which extends southward from Latammar to Bannu. Its flatness rendered it difficult to find or fix points along the western edge of the district, but the few that could be fixed were sufficient, with the well-known peaks of the Lawághar hills on the east, to enable Mr. McNair to plane-table all this area. The peculiarity of this part of the Kohat district is its waterless character. In the month of March the Kummor wells form the only water-supply for a distance of from ten to sixteen miles round, and the daily collection of people (chiefly women) at these wells in the early morning rather resembles a *méla* (or fair) than anything else. The water is carried in small goat-skin *mussaks* on the backs of donkeys, long strings of which, driven by women, who are generally handsomely dressed, with a profusion of silver ornaments on their breasts and arms, may be seen in the early morning, converging to the wells from every point of the compass.

Remarks on the country plane-tabled.

The country plane-tabled consisted of the upper valleys of the Kohat and Teri rivers, the Surdág hills, and the Lawághar hills, with the low-lying plains at their foot on the west, bordering the Bannu district. All the smaller tributaries of the Kohat river, as well as the main stream of the Teri, flow generally from west to east towards the Indus, in approximately parallel lines, and through narrow valleys fairly well cultivated by means of irrigation. The hills dividing these valleys are rough and precipitous, their apparent formation being limestone, above which occurs a rock closely resembling laterite, which may be the pisolitic ferruginous clay referred to in page 563 of the "Manual of Geology of India." There is often great apparent regularity of outline, both in section and plan; and where the strata dip at any considerable angle, there is usually a sharp knife-like ridge defining the summit, which is difficult to traverse. But rough and difficult of access as they are, they are entirely free from heavy jungle, and possess great command of view over the surrounding country; so that this part of the district cannot be called difficult for plane-tabling. The general level of the cultivated portions is high, between 1,000 and 2,000 feet above sea level, and the climate cool and pleasant. The Surdág hills, stretching east and west below Bahadur Khel, are different in formation. They are red and purple clays and sandstone, overlying large masses of grey rock-salt, which is dug out of them for trade. They are peculiarly intricate in character, breaking up into minute detail, which is tedious and troublesome to define topographically. But they are also free from jungle: and difficulty of detail, when that detail is visible, is not to be compared to the difficulty caused by heavy jungle. The Lawághar hills are wholly sandstone, and run parallel to a range of hills called the Súrghar, which is almost wholly limestone. They are difficult of access, and the labour of making way about them is severe. The low ground west of them is open plain, almost entirely under dry cultivation, but very destitute of water. Throughout an area of some 300 square miles water is only to be obtained at 14 (out of 140) villages, chiefly from deep-sunk wells.

Forts, towns, cities, &c.

The only fort or town of any importance in the district are those of Kohat itself and the posts maintained along the frontier line to Bannu or in the Meranzai valley. The town of Teri is prettily situated on a small hill bordering the Teri river, and it contains a few strongly walled buildings. The command above the river is about 100 to 150 feet, but it is not a place of much importance. The chief lines of hills in the district have already been referred to. The ridge, of which Halwat and Swani Sir are the two principal peaks, the Surtang line of hills, the Surdág (already described), and the Lawághar, are the most definite of these minor hill systems. The Surdág pass, connecting Bahadur Khel with Latammar, is the only one of any importance falling within the limits of last season's work. Of other ranges it would be safe to record that they are impracticable. The Surdág pass is only a part of the main frontier road connecting Kohat and Bannu, and as such is well known and frequently traversed. None of the rivers

are navigable. They flow down to the Indus through steep, rocky defiles and high banks, and their beds seldom even afford foothold for a narrow path. The beds of the Kohat and the Teri streams are never absolutely dry. The Bungush and Khattak tribes divide the whole district between them. Both of them are Pathán or Pashtu-speaking people, and in manners, habits, &c., it is not easy to distinguish between them. As a rule they are frank, pleasant people to deal with, and there was not a single case of dispute between the surveyors and villagers during the last field season; but they are true Pathán, with regular Pathán love of border fighting and raiding. Blood feuds and reprisals are of constant occurrence, and lead probably to far more murders than the accidents attendant on robberies and raids. In appearance they are a sturdy-looking, well set up race of men and women. Their dress is flowing and picturesque, and, in the case of the women, often very handsome and well set off by heavy silver ornaments. They prove to be excellent soldiers in our frontier regiments.

Addenda from a Report by Mr. W. W. McNair.

I have the honour to submit a report of my reconnaissance of the tract of independent territory lying east of the Kurram river and immediately north of Edwardesábád or Bannu.

The tract in question embraces an area of 350 square miles, and through it from east to west extends the range of hills generally known as Laki Juni or Kafir Kot. This range, which consists generally of conglomerate, terminates at each end in huge excrescences of grotesque shape, which rise considerably above the level of the ridge and strike the observer's eye from every direction.

The four most prominent of these excrescences, perched as it were on the eastern end of the ridge, are collectively called Kafir Kot, an appellation which, I believe, may signify either the "infidel's abode" or an "inaccessible nest." I am informed their summits have hitherto not been reached.

One of the mounds on the western end of the ridge assumes a form not dissimilar to that of a well developed woman. This resemblance appears to have received local recognition in a legend, which attributes the peculiar formation to a forsaken maiden, whose prayer to be turned to stone was granted.

The heads of two streams, the Changos and Jangana, constitute the northern boundary of the tract of country, the subject of this report. The eastern and western boundaries are the Changos and Kurram rivers, and the southern a range of hills through which burst the Kurram, Goumati, Barganatu, and Changos.

The two streams, the Changos and Jangana, flow some distance in opposite directions. The Changos, after proceeding eastwards for about two miles, turns sharply round to the south and finds an exit through a range of hills, finally joining the Kurram six miles south of Bannu. The Jangana runs parallel to the Kafir Kot range of hills until it empties itself into the Kurram.

In my observations of the passes leading into the heart of this tract of country I was careful to notice that there were no obstacles calculated to interfere with the progress of wheeled artillery.

Throughout the entire area of 350 miles I noticed only four villages containing *permanent* dwellings. They were Goumati, Sapari, Shazman, and Garang; and I estimate there were about half a dozen other villages which consisted entirely of temporary structures.

The general aspect of the country is wild. Of cultivation there is very little. A very fair supply of water throughout the year, and grass in fair quantity, are to be had, but fuel is scanty.

The inhabitants are sections of the Daresh Khel Waziris, and are divided into clans, of which the principal are the Hati Khels, Utmanzai, Umarzai, and the Spinkhi Turi and Gagan Khels.

In winter and spring as many as 6,000 fighting men are estimated to occupy the hills, but during the hot months, from May to September, scarcely 500 remain behind, while the main body betake themselves to Shawal. For subsistence I have reason to believe the inhabitants largely rely on robbery, carried out on the Bannu and Kohat border. Their reputation as highwaymen is great, and I think I am right in saying they are a source of considerable anxiety to the Deputy Commissioners of Kohat and Bannu.

This tract of country is an asylum for all the bad characters and refugees from British territory; and whatever the price at which such men may secure shelter, the protection they receive is proof against all treaty obligation. On the occasion of my visit to Kafir Kot I was accompanied by some of the Nabab of Khattak's men, and from them I afterwards ascertained that one of the Daresh Khels, who engaged a good deal of their attention, was a murderer and a refugee from British territory.

The ostensible means of livelihood of the Daresh Khels is the sale of cattle and sheep, of which they possess large numbers, and the hiring out of camels. From the Bannu plains they draw supplies of the ordinary necessaries of life through permanent settlers located there by each of the above mentioned clans.

Like most Afgháns, the Daresh Khels are men of splendid *physique*, of great endurance, and inured to the inclemency of all weathers. I have not heard of any of their numbers accepting employment under the British Government.

Like all Muhammadans, their graves face north and south; but whilst all other sections of Afghâns erect two upright stones—one at the head of the grave and the other at the foot, with this distinction for that of a female, that they have the flat face of the upright stone at the foot turned towards the north—the Daresh Khel Waziris place three stones over the graves of their women and only two over those of the men.

Addenda from a Report by MR. T. E. M. CLAUDIUS.

I HAVE the honour to submit the following report of the working of the party during your absence from 27th November 1881 to 3rd February 1882, as also a few notes on the country plane-tabled by me. The programme left by you for the last field season was followed out as closely as possible. With the exception of Mr. McNair, who started a few days in advance of the party for Kohat, with the expectation of immediate trans-frontier work, and sub-surveyors Esuf Sharief and Kadar Sharief, who were employed by the orders of the Surveyor-General for about a month in plane-tabling on the half-inch scale a portion of the country between Nagtiba and Mussoorie, the party continued working at the Afghánistán fair mapping till about the 10th December. On the 12th I started with the whole establishment and reached Kohat on the 15th. The usual preparations for field work were taken in hand at once, and all the plane-tablers, fully equipped, started for their respective portions on the 21st. The plan recommended by the Deputy Commissioner, of supplying each surveyor with a responsible man from the police, with the authority for engaging a certain number of men picked from the ground on which each plane-tabler was to be employed, answered admirably, and was found even preferable to a military escort. On account of a severe attack of fever, which is always prevalent in Kohat during the winter months, I was unable to start my own plane-tabling till the 1st of January. Kadar Sharief, from an attack of rheumatism, was reported unfit for work a week after his departure, and continued in that state until your arrival. Mr. Warwick, who had been on sick leave, reported himself at Kohat on the 23rd January, and on the day following he accompanied me *en route* to his work, while I proceeded to inspect sub-surveryor Atma Singh, who had been making slow progress out of all proportion to that of the others. I found him employed in exceedingly intricate ground, and it was merely his want of experience in delineating such ground that deterred his progress. He is very apt though, and soon put into good effect whatever he was told. On my return to Kohat, I was surprised to find that Mr. Warwick was obliged to wend his way back on account of a relapse of sickness. He was never able to undertake any field work after that.

The area surveyed by me, 260 square miles, included Kohat itself on the north-east corner and the hill sanitarium of Mirkhwaili on the south-west; the former surrounded with smiling gardens and fields of luxuriant wheat cultivation, while the latter surmounts a mass of exceedingly stony and rough hills. My out-turn, perhaps, would have far exceeded what it did but for the scarcity of villages in my western corner, and the time thus lost in tracing and retracing my steps from and to camp morning and evening over cut-up and waterless tracks. The hill Mirkhwaili affords a cool retreat to a few of the inhabitants of Kohat during the summer months, and but for the extreme difficulty of conveying building materials to the summit would, no doubt, be utilized to a greater extent than at present. The only respectable building up there is the one Major Cavagnari took the trouble of erecting, and to this the fashionable society of Kohat are obliged to resort by turns.

Thieving, cattle-lifting, and murders are of course of frequent occurrence all along the Kohat frontier, but I was very much surprised at the daring displayed by some Afridis at Kohat in an attempt to steal my horse in the month of April after the completion of my work. Twice on the same night attempts were made, although on the first occasion they were fired at by my havildar and guard, and one would have thought that, having aroused everybody's attention, the attempt would not have been repeated, yet to our surprise a second and more daring trial was made to effect an entrance into the stable by digging a hole in the back wall. This of course was soon heard and discovered, but the thieves managed to make good their escape with a few ineffective bullets whistling after them.

As notes regarding my work of season 1880-81 were not sent in at the proper time, I trust they will not be considered out of place here. About a mile to the north-west of the well-known village of Jangal, latitude 33° 37′ 10″, longitude 71° 12′ 10″, there exists a most remarkable spring, situated at the northern base of a hill which terminates one of the longest spurs jutting out from the Langardarra range. It is a delightful spot, with a splendid grove of immense mulberry-trees growing around, and the large body of water, pure and clear as crystal, which bursts out of an excavation 5 feet long and 2 feet wide in a perpetual flow, gives the visitor a strong disinclination to leave such a beautiful spot after traversing the sterile tract all about. Great care is bestowed on the cleanliness and arrangements of the place; and not only has the usual marvellous tradition been handed down from father to son regarding its origin, but an extra amount of veneration and superstition is attached to the spot. The very fish in the immense pool immediately below the spring are worshipped, and nobody dare attempt throwing in the "barbed hook with its dainty allurement." The story repeated to me was that about 70 years ago "Kachai" (the name of that part of the country) was entirely devoid of water, when "Mír Rahim Syed," a very religious and devout man, promised to obtain the needful supply. A spring did exist, I believe, prior to Mír Rahim Syed's

promise, but the water which issued was very scanty, and of a milky appearance. The Syed, however, determined to emulate Moses and his rod, and after excavating a little himself, made good his entrance into the rock and disappeared. For a whole week he was not seen, nor could any one pretend to conjecture what had become of him. During this time, however, Mír Rahim was not idle, for he managed to traverse more than a mile right into the heart of the hill, and after the lapse of eight days he reappeared, but about 100 yards away to the west of his entrance, and on about the same level. Immediately on his reappearance the magnificent flow of water which continues unabated to this day burst out with an impetuous rush, and so not only the whole of Kachai, but villages farther eastwards, have all a plentiful and wholesome supply. After this exploit some return was thought necessary by the inhabitants for Mír Rahim's miraculous work. He was very modest in his own request, for he only asked for a piece of arable ground as long as the shadow that would be cast from a wand of his. This was readily and gladly granted by the people, for they did not expect to get off so cheaply; but to their indescribable astonishment, when the Syed planted his wand perpendicularly at one extremity of a field the shadow stretched far away for miles. A compromise was however made, and a tract of ground given him, which to this day is held by his descendants.

Regarding the passes into Tirah from the Kohat side there are three,—the route from Bar Marai, the Landukai pass, and the route along the Gorbin river. The Landukai pass is the most difficult, but the shortest, and the Gorbin river route the most feasible. From the village of Shou, six miles north-east of Hangu, the road is traced alongside the Gorbin river for about 20 miles until the large village of Kandi is reached. The route then strikes north across the Senpaghar range, over a rather low *kotal*, or saddle of the hills, and thence leads right into the heart of this little known country. As far as I could ascertain from numerous enquiries, this is the only road that, with little trouble, could be made practicable, not only for mounted batteries and cavalry, but also for laden camels.

Among the different clans inhabiting Tirah (of which a complete list is subjoined), there is, as usual throughout Afghánistán, a great deal of tribal animosity and jealousy. Constant bloodshed and pitched battles are more the rule than the exception; but perhaps the undying antipathy displayed by the Meeshtics towards the Mania Khels and *vice versâ* is unsurpassed even in Afghán feuds. I believe, as the former clan have invariably proved themselves the stronger, the latter have suffered so dreadfully at their hands that the clan is actually approaching a state of extinction. While on Kadumb H. S., observing and reconnoitring, I witnessed a regular pitched battle below on the north side between the Feroz Khel and Akha Khel clans, the former acting on the defensive. The attack was most determined, and the sound of musketry continued all day without interruption. I was glad I was not seen and disturbed, for I had a considerable descent to make and a great distance to traverse before reaching camp. This, however, I could not manage till 10 at night. The ascent was made at 3 in the morning. The whole of Tirah is well supplied with Snider rifles, and I came across a number of men on different occasions bearing well-cared-for Martinis. The owners were quite proud of their weapons. They boast that these rifles are plunder secured during the two last campaigns, both on the Khyber and Kurram routes. For the Sniders they appear to have such an abundance of ammunity that cartridges are actually bought from Tirah by men from our side of the frontier cheaper than they can be obtained by them in India. The manufacture of cartridges for the Martini has already been commenced by the Afridis of Tirah with great success, and I was shown one thus manufactured. The case is very similar to those manufactured in Kabul during the seige of Sherpore, and although rather thick and heavy, would stand any amount of reloading.

Tirah.

Clans.	Approximate population.	Products.
Alikhel*	3,000	Rice.
Mamozai	3,000	Wheat.
Shai Khan	2,500	Indian corn.
Malakel	1,000	Potatoes.
Alisherzái	3,000	Gram.
Meeshti*	3,000	.....
Rabiakel	700	Walnuts.
Akhel	700	Grapes.
Mamazi	400	Peaches.
Bar Mohammed Khel ...	2,500	Pomegranates.
Mani Khel	800	.....
Abdul Aziz Khel ...	300	.....
Sipahi	500	.....
Feroz Khel	600	.....
Bazoti	500	.....

* Zeraitais, but combined with Urakzais.

Extract from he Narrative Report, dated 31st October 1881, *of* COLONEL C. T. HAIG, R.E., *Deputy Superintendent, Survey of India, in charge Guzerat Party.*

Of the country topographically surveyed sheet 76 is almost entirely Baroda territory There are but 8 small villages of the Pálanpur State. It is mostly flat and open, but in the north-east corner there are a few small detached hills and an area of 70 or 80 square miles; in the south-east it is pretty thickly wooded. The Saraswati or Kuwarika river crosses the sheet from east to west, and is a stream of some importance. Its banks are shallow, seldom more than 10 feet deep; but the width varies from 400 to 900 yards, with a considerable body of water always flowing in a more or less narrowed channel with a velocity that strikes one as being excessive for the apparent gentle, almost imperceptible, fall of the country. The Rájputána Railway crosses the sheet from north to south through the eastern half, where it taps a very populous district. There are two railway-stations in the sheet, Sidhpur and Unjha, which towns have respectively populations of 13,600 and 10,500. About 20 miles to the west is Pátan, with a population of 32,600. There are two other towns of populations between 4,000 and 5,000, two more between 3,000 and 4,000, six between 2,000 and 3,000, twenty-eight between 1,000 and 2,000, and of course very many smaller villages. This part of the country is full of historical interest. Pátan is built on part of the site of Anhilwáda, the old capital of Guzerat before Ahmedabad was built. Anhilwáda is said to have been a city 18 miles in circumference, and the heaps of old ruins and bricks to be found for miles round Pátan seem to corroborate the statement. Sidhpur is a noted place of pilgrimage, and the remains of the Rudra Mala Temple of Shiva are an object of considerable archæological interest. Sidhpur and Pátan are both on the Saraswati river, which is itself venerated as a goddess.

The area embraced by sheets 35 and 36 is divided between British Baroda, Bánsda, and Dharampur territory. It is traversed by the Purna, Ambika, Káveri, and other smaller rivers, which, with their many tributaries and feeders, make the country very intricate and difficult for the surveyor. It is wooded also, and the east of sheet 35 and the adjoining strip of sheet 49 between it and the Dángs is hilly country. The railway-station of Bilimora is just inside the western margin of sheet 35; the railway, following the general trend of the coast, enters sheet 35 two miles north of Bilimora, and leaves sheet 36 about six miles to the south. From Bilimora is a made road of 29 miles in length to Bánsda, forming the chief outlet for the timber from the Dángs. On this road, at six miles from Bilimora station, is the British taluka town of Chikhli, and about two miles north of the road, from a point about three miles from Bilimora station, is the Baroda town of Gandevi, of some importance from its size, having a population of over 7,000. The State town of Dharampur falls in sheet 36, having a population of 4,470. The population in these parts consists largely of Bhils and such like folk, who prefer living in huts, apart, or in groups of two or three huts, which adds much to the surveyor's trouble, particularly as the country is fairly thickly populated. Bilimora has a population of 4,442, Chikhli 3,153, and Naldhara, a Gaikwari inami village, 3,650. Besides these, there are in sheet 35 and the half of sheet 36, thirteen towns and villages of populations between 2,000 and 3,000, and fifty of populations between 1,000 and 2,000, and a multitude of smaller villages; but even the populations of the large towns contain a considerable Bhil element, which is scattered in huts over the fields.

There is in sheet 35 a hot sulphur spring at a place called Unái, on the boundary between the Baroda and Bánsda States. The following mention is made of this spring in the "Imperial Gazetteer," volume I, page 402:—"At Unái, within the limits of this (Bánsda) State, is a hot spring, the temperature of which is generally but little below boiling point; but once a year, at the time of the March full moon, the heat abates sufficiently to allow a company of pilgrims and devotees to bathe in it." This is the popular account, but it states too little and too much. The bathing takes place on the day of the full moon of the Hindoo month Chaitra and the two following days; and if during all the rest of the year, as is commonly said, the temperature of the water is but little below boiling point, here is a miracle indeed; and the phenomenon is popularly ascribed to the power of the local goddess of Unái, Matha, in whose honour thousands congregate at an annual fair. I was in camp not far from Unái very shortly after the fair this year. The new moon occurred on the 3rd April, and the bathing took place on that day and on the 4th and 5th. On the 11th I took the temperature, which was said to have returned to its normal height on the 6th, and I found it to be 138° Fahrenheit, considerably below boiling point. I was informed by a Bánsda official at the place that the bathing commences by a sudden rush into the water of some hundreds of Bhils and others, who previously fortify themselves with an intoxicant drug (*bhang*, hemp), and that this cools the water, so that the bathing can afterwards be kept up by the continual stream of the visitors to the fair—men, women, and children—who plunge in but for a moment and so keep down the temperature, for they continue all through the night. This is confirmed by a Mahommedan sub-surveyor who witnessed the first rush last year. If this is the only explanation of the phenomenon, to my mind it leaves it yet to be explained how people, in whatever numbers, can plunge into water at 138° without being seriously scalded, which does not appear to be the case, though, as has been proved on more than one occasion, a single individual falling in at any other time of the year meets his death. I was suspicious of some cold tap capable of being turned on in the adjoining temple by a local Brahmin on behalf of the local goddess, but could discover no appearance of anything of the kind. The spring is enclosed in a masonry tank or *khund* 50 feet by 45 feet, in which the depth of the water varies from 4 to 6 feet. The Baroda and Bánsda State boundary passes along

the edge of the *khund* where it adjoins the temple, so that the temple is in Bánsda an the *khund* in Baroda territory.

The portion of the Dángs surveyed this year consists of five sections of sheet 49, numbered 7, 13, 14, 15, and 16 on the index map. Captain Hobday, under whom the work was carried on, states that the character of the country is similar to what has been met with in former years, but perhaps the features are larger as one approaches the Ghâts. It will be seen from the index map that sections 14 and 16 reach the Ghâts where the Guzerat survey meets the North Deccan survey. The highest peaks at this part of the Ghâts are between 4,000 and 5,000 feet high, and Saler fort, which is about a mile south-east of the south-east corner of sheet 49, is over 5,000 feet. The chief river is the Purna, which rises at Saler and traverses the surveyed area in a north-west direction. The Eastern Dángs are more populous than the western, and the forest clearances are in consequence more extensive. On the plateau there was a great scarcity of water, and what little there was, was very bad. One principal road, by no means a good one, traverses the area surveyed; it is the continuation of the road from Bilimora and Bánsda to Garvi into Khandesh.

In the 42nd paragraph of my last year's report I mentioned an experiment made by Lieutenant-Colonel Leach and Captain Hobday with a water level, and stated my intention of giving the method a trial on a larger scale. I have now the satisfaction to report that out of the 10 plane-table sections surveyed in the Dángs this year 8 were contoured with water levels, and the method has proved a success beyond all my expectation. The time taken to contour these 8 sections comprising the south-east quarter of sheet 49, giving a contour at every 25 feet, was but very little more than it would have required to have surveyed the area on the old system; and now that the hands have been trained to the new method, I anticipate that they will be able to work quite as fast as on the old.

I must, however, here explain that the method differs materially from that of a rigorously contoured survey, inasmuch as that only the few contours near the tops of the hills and at the foot of the slopes were actually rigorously surveyed. A great many sections were taken, the principal sections starting from and closing on trigonometrically determined heights, and auxiliary sections emanating from the principal sections were taken down all convenient spurs, and sometimes down very inconvenient slopes when the convenient spurs were too far apart. The water-courses and the plateaux were of course carefully surveyed as usual, and the contours on the slopes were sketched in from section to section; the surveyed contours at top and bottom of the slopes enabling this to be done with great accuracy.

Extract from the Narrative Report, dated 20th August 1882, *of* Lieutenant-Colonel A. Pullan, *Deputy Superintendent, Survey of India, in charge Kattywar and Cutch Party.*

General aspect of the country.

Of the country topographically surveyed this season, sheets 17 and 18 are portions of the featureless salt "Rann" which I have already described in former reports. Sheet 19 contains the remarkable little island of Pachham. Having an area of 275 square miles, the island contains 19 villages, the largest of which are Khawada, population 1,222, and Kunria, population 525. Two ranges of hills, called Kala and Gora Dongar, run almost parallel from west to east. The island is surrounded on all sides by Rann and waste grass, and on three by shallow water for 8 months in the year. During the monsoon shallow water encloses the island on all sides. The remainder of sheet 19 is Rann and the level grass steppes of Banni.

Sheet 20 comprises a major portion of Banni, a grassy plain, dotted here and there with clumps of *babul*-trees and the huts of wandering herdsmen from Sind and Cutch.

Sheet 21 contains a portion of the Rann between Cutch and Banni, together with the belt of fertile ground which skirts Cutch on all sides; the remainder of the sheet is mingled hill and valley, rocky and poorly cultivated.

Rivers.

The principal streams in this season's work are—1*st* "Nagmati," rising in the hills near Kera in sheet 22 and flowing into the Gulf of Cutch; 2*nd* "Phot," rising to the east of Kera and flowing into the Gulf of Cutch at Navinal point; 3*rd* "Bhukhi" and "Sakra": these streams rise in the hills south east of Bhuj, flowing south and effecting a junction one mile south-west of Bhadresar town, and falling into the Gulf of Cutch near that place; 4*th* "Khári," takes its rise in the hills south of Mankua in sheet 22 and terminates in the sand of the Rann near Sumrasar village.

Hills.

Kala Dongar, the highest range in Cutch, is to be found in sheet 19. One peak, "Babia," rising to an altitude of 1,520 feet above sea level. The other ranges in this season's work are "Warar," with an altitude of 1,125 feet; "Jhura," 1,062 feet altitude; and "Habo," 974 feet altitude.

Towns.

The principal towns and villages in the season's work are—Bhuj (the capital of Cutch), a very pretty, clean town, picturesquely situated in a well-cultivated valley surrounded on three sides by low rocky hills; Bhujpur, population 2,892; Khawada, the principal town of the island of Pachham, population 1,222; Niruna, a large village on the borders of the Rann, population 1,444; and Bhadresar, population 1,943, situated on a creek two miles north of the Gulf of Cutch and remarkable for its very fine old temple.

Extract from the Narrative Report of MAJOR R. BEAVAN, *Officiating Deputy Superintendent, Survey of India, in charge Beluchistan Topographical Party.—Season* 1881-82.

Plan of detail. Survey operations.

THE work in hand on the 1st October was continued without interruption, and consisted of the detail survey, on the scale of half an inch to a mile, of the hilly country lying between Quetta and Kelat, adjacent to the Bolan and Rodbar passes. I received orders to accompany a military expedition, under Brigadier-General H. C. Wilkinson, to open out the routes between Thal Chotiali and Dehra Ghazi Khan. I also took advantage of such opportunities as occurred for filling in, on the quarter-inch scale, portions of country hitherto unsurveyed, and for getting observations to complete the Sewestan triangulation.

Arrangements for prosecuting the work.

The plan of operations already in force continued to work throughout the season, the only exception being that less assistance was available from the Military Department in the matter of transport and commissariat. This was partly due to the fact that our survey parties were gradually working further away from the military line of communications, and partly also to the reduction of troops and the curtailment of the transport and commissariat establishments consequent on the cessation of military operations.

We continued, however, to receive assistance from the Transport Department till January, after which we were able to hire camels at Sibi for work in the lower country and in the Marri hills.

Triangulation. Arrangements for—.

Owing to pressure of other work, and particularly the great importance of completing as much topography as possible during the remainder of the field season, it was not found practicable to advance with the triangulation in a systematic manner, or to employ any of the party on this work alone, but every opportunity was taken for completing the observations at the different hill stations selected for the purpose, as they happened to come within reach during the progress of the detailed surveys and reconnaissances.

Triangulation completed.

In this manner observations were taken at eleven stations, besides one hill (Bútúr), which was ascended and found to be well adapted for a station; but time was wanting for taking a regular series of angles, and no opportunity offered for revisiting the place Some difficulty arose from several of the cairns erected the previous season having been destroyed, but considerable progress was made both in improving the accuracy of the triangles previously laid out and in extending the series, which, starting from three stations of the Beluchistan series south of Sibi, spreads itself over Sewestan and the Marri hills, and will eventually join the Great Indus Series near Dera Ghazi Khan. There is only one hill near Vitakri which has not been actually visited in this series of triangles, but observations are still wanting at several stations in order to complete a satisfactory connection.

On the 14th October I received orders to accompany an expedition proceeding from Quetta to Dera Ghazi Khan *viâ* the Saoura pass. I obtained permission to start ahead of the troops, and left Quetta on the 25th October, joining General Wilkinson at Shahrag on the 7th November. In this interval I took observations at Khost, H. S., and succeeded in sketching in several portions of country that had hitherto been very roughly delineated. After this I accompanied the force on the march *viâ* Mandai, Shal, and Chamálang to Dehra Ghazi Khan, which place we reached on the 11th December. *En route* I visited and observed at Torgarh, H. S. and Dadar, H. S. (= Chamálang Sir:—Heaviside), and also visited Bútúr hill, but had not sufficient time for taking regular observations there. The results of my plane-tabling work during the march were embodied in a map which I prepared for General Wilkinson, and which has since been published.

On the 1st January the office was moved down to Pir Choki, at the mouth of the Bolan pass, and I went on with the triangulation, visiting the following stations during the month of January:—Kirta, Great Trigonometrical Station; North Band, Great Trigonometrical Station; Sangon, H. S.; and Nari, H. S. At the last named station, owing to cloudy weather, I was unable on this occasion to secure the observations I wanted, and had to visit it again later on. In February I observed at Khanki, H. S., and made arrangements for continuing the survey of the Marri hills with an escort of Marris furnished me by the Assistant Agent. Mr. Corkery having finished his work in the Rodbar pass, and being at that time in fairly good health, accompanied me, and we left Sibi on the 13th February. We marched *viâ* Talli and Daho as far as Tatra hill, a few miles north of Kahan. I took observations at Bagrai, H. S., and Tatra, and we returned *viâ* the Sart valley to the Chakar river. During this period it was necessary to carry provisions with us, not only for our men and animals, but also for the Marris, who accompanied us, and grain for their horses. I had arranged for a fresh supply of provisions to have been brought out with the 3rd Native Infantry who were marching in this direction, and they were timed to meet us on the 3rd March. They did not, however, leave Sibi till about the 6th, and my provisions were consequently delayed. I therefore decided to divide our party, and leaving the remainder of our provisions with Mr. Corkery returned myself towards Sibi, marching *viâ* Quat Mandai, and completing the observations at Nari, H. S., that I had been obliged to leave unfinished on the previous occasion. I returned to Sibi on the 13th March.

Remarks on the country under survey.

The whole of the country in which survey operations were carried on presents the usual characteristics of Beluchistan—dry and arid, with no vegetation; water very scanty; only procurable in certain places, and generally brackish; bare rocky hills and stony plains.

Duration and close of the field season.

The field season continued over 12 months; the party left Sukkur early in April 1881, and continued at work till nearly the end of March 1882.

There was no serious sickness during the whole of this time, but most of the members of the party suffered from fever more or less, and owing to bad food and water were seldom free from diarrhœa and mild forms of dysentery. Mr. Coxen had a serious attack of erysipelas, and Mr. Corkery was obliged to take sick leave to England in order to recover his health.

General remarks.

As explained above, the great object kept in view during the field season was to get as much topography completed as possible, and at any rate to complete the map of the hilly country which lies between the Bolan and the Rodbar passes on the half-inch scale. This was satisfactorily accomplished, and the results are now ready for publication, and in addition to this a great deal of new work has been done on the smaller scale of 1 inch = 4 miles for the purpose of incorporation with the maps previously published. To attain this result, however, it was necessary, in a measure, to subordinate the progress of the triangulation, which is consequently still in a somewhat incomplete form. When opening out a new country, a number of points fixed with moderate accuracy are of greater value than a few stations of which the positions are rigorously determined within an inch or so. The former can, moreover, be more expeditiously secured than the latter, and the observations necessary to secure rigorous accuracy can be taken at a future time if required.

In the Sewestan series the triangles have to be laid out on a large scale, the sides of several of them being 40 miles in length. This arises from the nature of the country, which contains a few prominent hills, and between them a broken irregular mass of smaller ridges. To establish stations on the latter is useless, as the rays from one to another get blocked by intervening ridges of equal height. Hence it becomes necessary to utilize for triangulation only the larger and more prominent hills, which are all mutually visible, but lying far apart from one another.

Under such conditions one might expect to attain a high standard of accuracy in the observations if only one could secure a clear atmosphere, but unfortunately this is very rarely to be had in this dry and dusty region. Thus it happens that frequently after a journey of seven or eight miles from camp, and a climb of 3,000 feet or so, some of the stations to which observations are to be taken are quite indistinguishable in a dusty haze, especially if there happens to be a dark background of more distant mountains. If in addition to this it should happen that the pile of stones which the observer is straining his eyes to detect has been destroyed by wandering shepherds, the chances are that he observes to some bush or rock, and does not find out till long afterwards that he has mistaken his point altogether.

Short Description of the Tract of Country in District Rawalpindi, known as "Kala Chitta Pahar," by Lieutenant-Colonel D. Macdonald, *Deputy Superintendent, Survey of India.*

"This range is in the shape of a wedge, entering the district (Rawalpindi) between Attock and Nara, where its width is about 12 miles. It comes to a point at its eastern extremity four miles due south of the Margala pass, and is about 50 miles in length. It lies in what is known as the 'Khattar' tract, so called after the 'Khattars,' an important tribe of the Awans."

"The 'Chitta' pahar is composed chiefly of nummulitic lime-stone, but the formation of many portions of its southern side is of soft sand-stone. The outer surface of the latter has, owing to the action of the atmosphere, assumed a dark, almost a black colour, giving it the name of 'Kala' pahar. The whole mountain is known as the 'Kala Chitta Pahar' (the black and white hills); but it is more generally called by the latter name."

* * * * * *

"It is more or less thickly covered with 'kow' (wild olive) and 'phoollah' (*acacia mæsta*). Grass grows plentifully on the lime-stone hills. A rich lime is the most valuable production of these hills. The trees are excellent for fuel and charcoal."

The above paragraphs are quoted from Major Cracroft's Settlement Report of the Rawalpindi district, dated October 1864.

It is a wild and gloomy region, not wanting, however, in the picturesque. The range at the eastern extremity is composed of low rounded hills. Proceeding westward, the hills increase in height and become more broken and rugged in their formation. The highest peaks, some of which range over 3,500 feet above mean sea level, are to be found in the north-western corner, abutting on the river Indus. The Indus forms the western boundary of the range, separating it from the Kohat district. As a rule, the hills in the north are higher than those farther south. The former are rugged, precipitous, bare on their summits, and rise in huge masses abruptly from the adjacent plains. Between these and the more southern portions of the range are a few open valleys, but not of any great

[illegible]. Then succeeds a series of rocky hills, very broken and disjointed. In parts they [illegible]t of narrow, almost perpendicular ridges of rocks, running in straight and parallel [illegible]with deep gorges between. Sometimes these ridges assume the most extraordinary [illegible]es. In one place their shape is almost elliptical, enclosing an elevated and oval plateau. [illegible]his again is varied by collections of isolated and conical peaks huddled together in the most inextricable confusion. Altogether the configuration of the ground in this region is very remarkable and unusual. A storm chart suggests a not inapt comparison.

It is a most desolate and inhospitable tract. Water is very scarce, and in the dry season hardly procurable, and of bad quality. It may at times be considered as an almost uninhabited region. There are no large villages in the interior. Hamlets, consisting of half a dozen rude huts, are few and far between, and only occupied during the rains, when water and fodder are procurable for cattle. The communications, once you leave the beaten tracks, are atrocious. These foot-paths, if they can be so called, which connect one hamlet with another, are hardly traceable on the rocky soil. A guide well acquainted with the locality is indispensable. These paths in their sinuous courses traverse all kinds of ground; they run over huge boulders, through clefts and fissures of rock, and along the dry and stony beds of mountain torrents by turns. Walking in these parts is certainly the safest, and often the only possible, mode of travelling.

The principal roads through these hills are four in number; by far the best is a metalled road from Campbellpur and Attock to Pind Sultani on the Rawalpindi and Kohat road. This can be used for wheeled carriage throughout its entire length. Near its entrance into the hills, and again at its exit, are two halting places, where there are large seraies for native travellers, with accommodation for Europeans in a corner. "Choi" is the name of the camping ground to the north. The other halting place is "Lambadan." Midway, in the very heart of the hills, at a place called "Lall-ki-ban," is a bungalow on the road, occupied by a customs officer.

The other roads are—

1*st*. From Fatahjang, the head-quarters of a tahsildar on the Rawalpindi and Kohat road, to Hasan Abdal.

2*nd*. From Fatahjang to Campbellpur.

3*rd*. From Campbellpur to Gaggan, a camping ground on the Rawalpindi and Kohat road, one march west of Fatahjang. All these three roads are very inferior, and can only be partially used for wheeled carriage.

Animal life in these hills is not very plentiful. A species of wild sheep, called "orial" or "horial," is found in some parts. "Chikor," or hill partridge, are tolerably abundant. There is also a smaller bird, a kind of partridge, called locally "soosee." Sand grouse, both large and small, are found in large numbers in the adjacent sandy plains.

This region is alluded to in Major Cracroft's report as a place "where crime flourished." "Many deeds of violence," he says, "were perpetrated with impunity; the robber, the murderer, and the offender against the State, found shelter here." He adds "that it is only in recent years that life and property have become secure."

The heat in summer is said to be intense, and no wonder. This can easily be accounted for by the absence of moisture in any shape, the hills being composed of huge masses of bare rock, and the adjacent plains consisting of a sheet of almost unadulterated sand.

The total area of the tract known as the Kala Chitta Pahar, inclusive of hills and plains, amounts to 531·3 square miles. The following table shows how this area is made up:—

				Square miles.
Government forest reserves	...	...	...	154·1
Sirdar Fatteh Khan's jagir	...	...	...	4·3
Five village of tahsil Rawalpindi		...	...	23·2
Twenty-six ditto	Fatahjang	...	...	127·0
Eighteen ditto	Attock	...	...	120·9
Six ditto	Pindigheb	...	...	101·8
		Total	...	531·3

Notes taken during the Field Season of 1881-82 *by* Mr. G. W. Jarbo, *Assistant Surveyor, when engaged on the Forest Reserve Survey in District Tharrawaddy, British Burma.*

The tract of country in which the survey party operated is known as the Thonezeh and Koonbeeling reserves. The former is bounded on the north by the water-shed between the Beeling Toung and Thonezeh streams, which is one of the main spurs of the Yoma; on the south by the Meening *Kyoung;* on the east by the Pegu Yoma range of hills; and on the west by the water-shed between Koonbeeling and Thonezeh streams, a continuation of the spur which forms its boundary to the north. The latter, Koonbeeling reserve, is bounded on the north by the water-shed between the Kadeen and Koonbeeling *Kyoungs;* on the south and east by the Thonezeh forest reserve; and on the west by a demarcated line which is shown by mounds of earth, four feet high, heaped round posts about five and a half feet high, on which are nailed zinc plates with numbers cut into them in the Burmese character.

The Thonezeh reserve is in fact the valley of the Thonezeh *Kyoung*. Being a surrounded by hills, the exhalations from the forests are so confined that this piece of co is more than ordinarily malarious. The difference of temperature experienced by surveyor, who has perhaps been marching during the great heat of the day along Thonezeh stream, when he reaches the summit of the Yoma hills towards evening and inhales the sharp breeze (which I have invariably observed prevails there from sunset to sunrise), is indeed great, and is of itself enough to try a strong constitution.

This tract of country of hills and vale is for the most part covered with dense and nearly impenetrable jungle, and, as observed by the Assistant Commissioner of Beeling, "is impassable for ordinary beasts of burden all the year round, and for men during a great part of it." The only clearances are those made by Karens; and were it not for the six Karen villages, which are all confined within one block of about 20 square miles in area, the whole of the country surveyed is a lonely region, uncheered by the presence of man; and its perils are realized when one thinks of the sad fate of two poor khalassies belonging to the survey, one of whom, whilst out with me this year, surveying along the Yoma, was attacked by dysentery and was first missed when we had encamped for the night after finishing the day's work. On hearing this, next morning, I ordered the mahouts, who were returning with the elephants to the standing camp at Weh village (as it was found impracticable to take them further into the hills), to pick up and take the missing man, Bodhee, with them. On my return to camp, days afterwards, I learned that he had not been found. As a batch of men were on the point of starting to remeasure traverse lines, they received strict orders to search all about the place where Bodhee was first missed, and a second party was also sent. The first failed to obtain any trace of him, but the latter discovered his remains within a few yards of the survey lines; they were partially consumed by jungle fires, which had also burnt his purse, for its contents, nine rupees, were lying under the body. The second man, a line-cutter, while travelling through the jungle, had felt feverish, and told his companions that he would seek for a little water, drink, and rejoin them; but he has never since been heard of. He doubtless lost his way, and eventually perished from starvation. It is unlikely that he has absconded to shirk work, as do some of the Boonias, for he was a well-conducted man from the North-West Provinces, whose friends have since written to know why he has not returned home for the recess season. Moreover, he had left his belongings, cooking utensils, &c., which for one of his class were valuable, at the main standing camp; besides a month's pay from Government, and other sums due to him from one of the establishment, have never been claimed by him. A third man was also missed early in the season, who, I now think, was lost in the jungle and died; but as he left no property in camp, and had little or no pay to receive, it is possible that he may have become frightened at the wild country and absconded.

Of the hills, the principal range is the Yoma (*i.e.* backbone). Its average height here is from 2,000 to 2,800 feet above sea-level. The width of the ridge at its summit is in most places but three or four feet. The southern and western slopes, and main spurs in the same directions are, as a rule, more steep than those of the north and east of the range. So precipitous are they, that there are but few places where one can cross from the Tharrawaddy to the Okhan side of the Yoma without cutting a series of steps to enable one to climb the ascent.

Among the more important streams which drain the Koonbeeling reserve may be mentioned the Koonbeeling and its feeders, the Kyouktaga, the Shawdon, and the Hmya *Kyoungs*; whilst those in the Thonezeh reserve are the Thonezeh and its affluents, the Nat and Kadogway *Kyoungs* on its right bank, and the Yaygyee, the Gonyin, the Thabyoo, and the Bawlan streams on its left. Streams are the only highways through the forests; with the exception of a few dragging tracks, it is by them that timber is brought down to still larger streams, till eventually it reaches, and is landed at the depôt where it is sold or sawn up. The dragging tracks, which for the most part run along the tops of some of the spurs of the Yoma, are few in number. They are the rough roads over which logs are dragged by elephants or buffaloes to the beds of streams, there to await the rainy season, when the rush of waters carries them into larger rivers to be floated on as before mentioned. One peculiarity of these streams is their narrow mouths at the confluence with the large streams. For instance, when travelling along the Thonezeh *Kyoung*, the narrowness of the mouths of its feeders would lead one to suppose that no streams worth surveying flowed into it. This is found to be an error on following up the seeming rivulets, for they are almost as wide as the Thonezeh river itself, their beds often measuring 100 and 150 feet in width. These are sometimes so nearly level and so neatly gravelled, that for some miles they remind one of a well kept drive through an English park; at other places, they have the appearance of being paved with petrified trunks of gigantic trees. Where they are very rocky, or are broken by water-falls, as are the Koonbeeling and Thanay *Kyoungs*, they are not considered, from a forester's point of view, as being "first-rate floating streams." The difficulty is often overcome by blasting the obstruction.

The forest is mainly a bamboo one, but there are fair quantities of teak, pajukadoe, pymma, thingan, and kanyin; whilst the banks of many of the creeks are interlaced with canes varying in thickness from that of a man's arm to the smallness of an infant's finger. Of the bamboo there are several varieties; if they are all valuable to the paper manufacturer, as they are said to be, there are here sufficient quantities to keep his mills at work for years without going further afield. Bamboos may be cut from the reserve by paying four annas for every hundred. Within this portion of the forest reserves I have not seen teak-

[illegible]s (*tectona grandis*) of any great girth, nor in any large quantities: in fact, of two strips of country, say a mile wide along the two sides of the reserve boundary line, I am sure that the one without the reserve holds more and better teak than that which lies within. This is not likely to be true a few years hence, as Karens are allowed and encouraged to clear and cultivate for their own use, temporarily, any suitable portions of jungle land, on condition that they plant them with teak, for which they are paid at a liberal rate per hundred.

As respects size, the most striking tree is the *kanyin*, known in India as the *gurjan* tree. From it is extracted an oil said to be a cure for leprosy. It is also used by the people for their lamps and torches. The Assistant Commissioner of Beeling says that "in manufacturing torches decayed wood is triturated and saturated with the oil. This is then rolled up in leaves of the *paloo* palm, much after the fashion of the ordinary maize cheroot, and tied up at intervals of two inches with bamboo withes." When burning, they give out an aromatic odour. They sell for about three rupees a hundred. The method used in extracting the oil is this:—Two or three notches are cut into the heart of the tree; from the lower portions of these notches the wood is scooped out, forming a rude cup; fire is then applied inside the notches, the heat of which causes the oil to exude into the hollows, from which it is removed in earthen vessels or in hollow bamboos. At night, in the depths of a dark and dismal forest, it is a weird spectacle suddenly to come upon half a dozen nearly nude natives extracting the oil; their faces look distorted in the lurid light of their torches, while in silence they move round their black and gigantic victim. It deludes one into believing oneself a witness to the sacrifice of a human being to some bloodthirsty deity.

A peculiarity of these forests, which is sure to be remarked by any one who has roamed much in those of India, is their scarcity in fauna. There are a few pheasants, partridges, and jungle-fowl, some beautiful birds as the trogon and parrot, and also some gorgeous butterflies; but deer and the larger *feræ* are rarely met with to the west of the Yoma hills, although the forests on their eastern slopes have been called the homes of such animals. That elephants and wild buffalo abound on the Okhan slopes I am convinced, as I have seen numerous tracks of both animals, and have even heard the trumpetings of the former. Here I would mention that I have both seen and heard guinea-fowl in these jungles. In doing so, I am aware that it will be said I have mistaken the silver pheasant for that bird; but, as others have on several occasions recognized them too, I can only think that, if they are not indigenous to this country, they must be the descendants of birds that have escaped or been freed from captivity.

From the almost total absence of animal life in the Thonozeh forests, day is oppressive in its solitude; while to the silence of the night is added an abnormal darkness, due to the density of the undergrowth and overhanging foliage.

The Karens, the only inhabitants of these parts, are a wandering race of people, who remind one very much, from their similarity in features, clothing, and habits, of the Mechis of the Western Dooars of north-east Bengal, and the Tharoos who live in the Tarai of the Oudh forests. In passing, it may be worth remarking that "Taroo" is the name by which one of the clans of Karens are known. The men are of finer physique than the Burmans, and the Karen women more handsome than the average good looking Burman lady. I have not seen one deformed, nor even thin, person amongst them. The clothing of the men consists of a cotton garment closely woven in one piece; this is almost identical in shape with the smock-frock worn by an English farm labourer. It is usually of two colours, a dull crimson and a whitey brown, in alternate broad stripes horizontally, and reaches down to the ankles. The women besides this wear a petticoat of the same material beneath it when out of doors; but, as a rule, when at home, they discard the tunic, wearing only the petticoat, leaving the upper portions of their persons nude. The children require no clothes; their fatness keeps them warm, decency being quite a secondary consideration.

A Karen village consists of but one house built on bamboo piles from eight to ten feet above the ground, with bamboo mats for its walls, and bamboos, not grass nor leaves, for the roof. This house has a passage from one end of it to the other, into which rooms open from both sides, the number of them varying with the number of families inhabiting, or having a separate interest in the village, the size being regulated by the number of individuals in a family. Access is had to the upper part of the house by a very narrow bamboo ladder, or sometimes by a limb of a tree with a few notches cut in it to answer for steps. This is placed in so nearly an upright position that it requires some agility to be able to climb it. The space below the house, literally the ground floor, is utilized as a hen-coop, pig-sty, dog-kennel, and latrine. It is therefore fortunate, on sanitary grounds, that the Karens remove their *tays*, as these villages are called, to a more or less distant spot every year without exception. On these occasions the old house is burnt, propitiatory offerings are made to spirits, which the Karens believe may perhaps haunt the new location they have chosen; a great feast is eaten and numerous libations are poured out. The community in a body then take up their residence in the new abode. The *tay* is known by the name of its living "Sookay," as their chiefs are called. On the death of one chief, the village is renamed after his successor. This custom is common to the *Mechi*. The Karen too, like the *Mechi*, has the habit of wandering at his own sweet will from place to place in the forest. When he comes to a spot which takes his fancy, he cuts down the trees, and, after burning them and the jungle, he sows rice in the ashes, barely sufficient to yield a crop which will suffice for the yearly consumption of his family and furnish enough for the next year's sowings. He also

cultivates cotton for his clothing, a few vegetables, and some tobacco ; while the small sur[illegible] realizes from the sale of betel leaves with an odd rupee or two, which some of them occasionally earn from forest contractors, procures him his luxuries, such as "ngapee" (fi[illegible] paste) and the areca-nut. In a year's time he thinks he ought to remove to another part of the forest, where he repeats the operations mentioned above. It is as well therefore that, since the formation of this forest reserve, he has been obliged to confine his timber-cutting propensities to the clearing of that land only which within certain ample limits has been set apart for him.

The Karens are filthy in their habits, dress, and persons. They are, as a rule, extremely indolent. Sowing and reaping their crops and building their houses occupy very few of the twelve months; their spare hours, when they are not drunk on liquor distilled from rice, are spent in smoking and gossip. The women weave cloth and make very neat and durable baskets, the shape and make of one kind is identical with the "kilta" made by the hill-men in the Himalayas, and resembles an exaggerated strawberry pottle. The Karens evince great curiosity on the occasion of an European encamping near their *tays*. They come over and ask all manner of questions, inspect his tent and belongings, and they will even touch one's clothes to examine and descant upon the texture and quality of the cloth. Some to whom I shewed the figures of a pattern plate from the *Young Ladies' Journal* were highly amused. They are a hospitable race as far as their means will allow, but have a dislike to selling fowls or rice, probably because the supply is limited in these parts.

In religion they profess to be Buddhists, but they seem to be very lukewarm in their belief. Knowing that many Karens had become Christians, I asked some of them why they too did not change their creed. They answered that no one taught them the new religion. I have heard that many of them, who were once converted to Christianity, have since relapsed to what, owing to their ignorance of even Buddhism, may be called *nothingism*. I believe that the present of a bottle of brandy would, for a time, decide the religious belief of a whole village in favour of any proposal by the donor. The *British Burma Gazetteer* gives greater and more interesting details of the Thonezeh forests and its inhabitants than any I could collect in a short field season.

Of the difficulties in the way of surveying, sickness is the greatest—

> "For hot, cold, moist, and dry—
> Four champions fierce—
> Strive here for mastery"

The superabundance of water in the wet and its scarcity in the dry season, and the impossibility of procuring supplies on the spot, may also be mentioned.

Not only were malarious fever and dysentery very prevalent, but the khalassies suffered much from sore eyes and swelled legs. The former is, I think, caused by the fluffy hair of the bamboos getting into the eyes, and the latter was most likely due to the scratches of poisonous thorns, drinking bad water, or perhaps to scurvy induced by the sameness of diet for months together, with not even an occasional dish of vegetables to give a relish to the monotonous meal of rice. Two of the survey khalassies lost their sight, whilst many who were hale and hearty when they joined the party returned home crippled. The want of water in the hot weather is a great hardship. It is not so much that water is scarce, as being unable to find it when it is required, that constitutes the difficulty. The time and toil spent in searching for it down the valleys, after a long and hard day's work on the hills, is very trying, and having to climb the ascent again and then cook their food robs the khalassies of hours of well deserved rest after the fatigues of the day. And often when the water is found it looks like a strong infusion of tea, and is most likely impregnated with *bacilus anthracis*, the fatal germs of splenic fever.

As regards supplies, they must all be imported from a distance. Elephants may be employed to bring them to the foot of the hills; but once arrived there, porters must be exclusively engaged; and as one man can only carry sufficient rice for the consumption of himself and two others, it follows that a surveyor's squad, which has usually eight men in it, must be increased by eight others, when started on a piece of work which it will take fifteen days to complete. This and the short period during which work can be carried on in this part of the country materially affect the season's out-turn.

Report by MAJOR W. F. BADGLEY, *Deputy Superintendent, Survey of India, on the Survey of part of the Burma-Manipur boundary, dated February* 1882.

I HAVE the honour to send the following report on the survey of part of the Burma-Manipur boundary.

Mr. Ogle (who was deputed with me for this work) and I left Shillong on the 4th of November with a sufficient number of survey khalassies to carry our instruments, and 59 Khasia coolies for the carriage of all baggage, public and private. Our intention was to have made four marches eastward from Shillong through Jowai and along the old Asalu road, and then to have turned south-east towards Cachar, by doing which we would avoid all but one march in the plains, which it is always advisable to do when travelling with hillmen as coolies. But on arrival at our fifth halting place we found that the village had certainly been moved from the place it used to occupy according to the map; and as we went farther we found on enquiry that the whole of the country south of the old Asalu

[redacted] between the meridian of 93° and the western boundary of the Cachar hills was quite [redacted]ted, all the inhabitants having moved eastward. As our supply of food depended on [redacted] we could purchase day by day, we also had to continue our march eastward through [redacted]opulated country nearly to Gujong, the head-quarters of the sub-division, before we [redacted]uld find a path to take us to Cachar, where we arrived on the 15th November. Here we found that it would be necessary to carry our supplies with us for the seven days' march to Manipur; and as the Deputy Commissioner would supply no coolies except at the prohibitory price of Rs. 50 a load (each cooly carrying half a load and receiving Rs. 25 pay), we had to wait for men from Manipur, which delayed us just a week. We arrived at Manipur on the 27th November.

For the next eight days our men were employed in clearing and putting up signals on old stations and at points chosen by us for our triangulation; and on the 6th and 7th of December, respectively, Mr. Ogle and I left Manipur to carry forward the work.

Starting from the stations of Yongbalong-Kong and Phunan in the Manipur valley, we arranged to carry a series of triangles eastward to the neighbourhood of the Kungal thana on the disputed boundary, where Colonel Johnstone, Political Agent and Boundary Commissioner, had established his camp, Mr. Ogle taking the northern stations of the series, and myself the southern.

For the first three days after leaving Manipur I had nothing but trouble. On the morning of my start my coolies were late, as is usually the case when making a fresh departure, and we did not get off till nearly nine o'clock, which was a bad beginning, as they had a very long march of 25 miles before them. My own route led by a detour past the Phunan hill, ten miles south of Manipur, where my triangulation was to begin. After climbing Phunan to the station and setting up my theodolite I turned the telescope to search for the first of my new stations, and found that the hill had not been touched, but that, through laziness probably, my cutters must have been taken to a low hill at half the distance, on which I saw a signal put up. I arrived in camp by torchlight. My Khasias came in after nine at night, and the Naga coolies with provisions, not at all. On the two following days I was taken, much against my judgment, a long round in search of the hill I wished to put up my station on, and at last reached it to find that I was only half a march from where we had started. After this I had an explanation with Soppa *subadar*, who had been sent with me as manager of cutters, carriers, and supplies, and had very little trouble of this sort during the rest of my journey, for which, indeed, I am much indebted to him, as without his excellent management I should certainly not have accomplished so much as I have succeeded in doing.

I was much disgusted on the night of my first march, as well as on several occasions afterwards, by the conduct of the Manipuris towards coolies and their Naga tributaries generally. There is much good, no doubt, in their rule over their Nagas. They prevent them from slaughtering one another, protect them, encourage them in agriculture and trade, and employ them as auxiliaries and in repairing and opening roads; and among themselves the Nagas seem well-to-do and happy enough, but the Manipuris treat them like dogs. On this occasion the man in charge of the thana would give my coolies no firewood. Looking as I do on my coolies as the legs and arms of my service, on whose well-being the success of my work mainly depends, I was particularly irritated, and the more so because I could not help them, as the man said that there was no more, which I knew to be untrue. It was 10 o'clock on a pitch-dark night so there was no use in their going out to search, even if they had had no march to tire them during the day. I did what I could for them by giving them the wood that had been brought for my camp fire, but my khallassies did much more: they gave what had been given to them for cooking and went dinnerless to bed, and they did this of their own free will and without my knowing of it till I heard it casually next day. This illtreatment of coolies is not an exceptional case. It happened whenever it could happen; and it is the rule that a cooly shifts for himself in the matter of fuel and food, no matter where he may be. Towards subordinates the Manipuris are always very overbearing, and they are very inhospitable to every body. At the end of one of my last marches back to Manipur, I arrived in the evening at a thana where I intended to halt. After a little talk with the thanadar I proposed to rest myself in the thana till my camp came up. I was told that I could not do so, but that a cow-shed would be cleared out for me to sit in. I hope that all my remarks on this were faithfully translated by my interpreter; not knowing Manipuri I cannot say, but some were, as they began to bustle about and turned some of their men out of one of their houses and made me comfortable in it opposite a good fire.

At the village where I encamped on the second day of my march I saw some trophies which had been brought by men of the village who had been among the Kuki contingent which Colonel Johnstone took to relieve Kohima. They were two Naga skulls and looked particularly fantastic, as the small trees on which they were set up had, either through accident or design, been so cut that two branches only remained, and these with their twigs looked like arms and fingers stretched out and thrown up in the air.

Not having been able to do more than a little triangulation at Phunan, my work actually began on the 9th at Sanachiug hill, which I made my men and the Nagas from the village near work at so hard, that though it was covered with forest I had it cleared and a signal put up by noon next day, and was afterwards able to do some good work, at the expense, however, of again finding my way to my camp (which I had sent on) by torchlight. On the two following days I cleared some points for plane-tabling, and on the 12th and 13th

cleared, set up a signal at, and observed from a hill named Manchuibung. Up to the 18[illegible] was engaged in having two more hills cleared for stations, and in returning to Sanaching [illegible] Manchuibung for their triangulation. As Colonel Johnstone wished me to come to his ca[illegible] as soon as possible for the actual boundary work, I worked very hard here, and I th[illegible] almost the hardest day's work I have ever done was in reobserving at Sanaching. I le[illegible] my camp at the Turet river, went up the hill, did my triangulation and plane-tabling, and came down again. The distance was about eighteen miles, with 4,500 feet up and down again, and it took from sunrise to near nine o'clock at night. On the evening of the 18th December I arrived at the Kungal camp at the northern end of the Kabu valley, where the disputed boundary, which the Commissioner had come to settle, lay; having up to this cleared five stations, observed at three, and plane-tabled about 280 square miles of half an inch to the mile topography.

During the next few days I reconnoitred the boundary with Colonel Johnstone and sent working parties to endeavour to clear two points on the Angoching range, which lay on the eastern side of the Kabu valley opposite our camp. The range is in Burmese territory, and my men were sent merely as an experiment, and unarmed, to avoid any chance of collision. They were turned back by armed patrol parties of Burmese. Mr. Ogle came into camp on the 24th, having cleared and observed at four stations and plane-tabled about 200 square miles, which, joining on to the north of my work, completed both the triangulation and topography of the country between the Manipur valley and the disputed boundary.

These days of comparative rest were very agreeable after our hard work, and we all passed Christmas together. Besides Colonel and Mrs. Johnstone we had in our camp Mr. Phayre, Assistant Commissioner; Dr. Watt as Botanist; Mr. Oldham as Geologist; Captain Angels, of the 12th Khelat-i-Ghilzaies, of which regiment we had 250 men as well as some police; Lieutenant Dun, of the Intelligence Department; and Mr. Ogle and myself, of the Survey: and with so many together, and of varied ideas, the time passed very pleasantly. Colonel Johnstone was meantime unsuccessfully trying to open negotiations with the Burmese officials, and as a last resource it was determined that Mr. Phayre should go to Samjok to see the Rajah, who seemed more obstructive than the others, and I immediately proposed to go with him, thinking that both profit and pleasure might be had from the trip.

On the 27th December Phayre and I started, making our first march to Morlung, about sixteen miles nearly south of the camp. He had written a letter to the Samjok Raja to say that he proposed to visit him to talk over matters, and on the way we met the messenger with the answer, which was conveyed in ambiguous terms, the clever use of which the Burmese rather pride themselves on, and was so very vague that we had almost turned back, as we did not know how the man might receive us, and we had no intention of allowing our dignity to suffer from want of the observation of proper etiquette. However, on arriving at Morlung, the chief man, who was a relation of the Raja, and who had come out to Thanan, about four miles, with all his armed following to meet us, received a confidential letter to say that the Raja wished to see us. At Morlung they treated us most hospitably, as they did everywhere else in Burma. We had given them no notice of our coming, or they would have built a special house for us; but they fitted up the travellers' house with cloths as curtains, and though it was a small village of merely twelve or fourteen houses, they gave us three maunds of rice, a heap of vegetables, salt, fowls, and half a gallon of honey, and would have been grievously offended if we had offered payment. Hospitality is a trait of the Burmese. In every village there is a traveller's rest-house, which is free to all, and a Burman, they say, will sell his coat to entertain a friend. In every village also there is a monastery, where, I believe, the village children are taught without fee by the priests, who are forbidden to touch money and live on what is given to them as food by the villagers, and which they beg from day to day, doing this not because of poverty, but because of religious rule; some of them always being well off, as I believe it is an institution that every young man, son of a person in good circumstances, shall pass a year or two in study among the priesthood. They shave their heads, wear saffron-coloured robes, and are not allowed to speak on public matters. Of common beggars I did not see anywhere we went in Burma.

At Thanan, which we passed through on our way to Morlung, we saw a coffin supported on stakes outside the village, and were told that it held the corpse of a very old man who had lately died, and that as his funeral ceremonies, on account of the honour due to his great age, would be very long, his relations had obtained permission to postpone them till after the harvest. The Burmese burn their dead.

On the 28th we crossed the Angoching range to Toungban, where the rest-house had been got ready for us with curtains and an awning of leaves set up in front of it. This village is on a little river, the Nat-than-yit, which being translated is "The crazy fairy's son." We came across the fairies several times on our visit. At Morlung there is a salt spring which had burst out of the hill-side after an earthquake, and we were asked not to go too near it with our shoes on for fear of offending the resident fairy. Phayre had a pony with him, and in riding through a narrow pass was asked by our guides to dismount till we came to the other end, as they said the fairy would, if not thus propitiated, bring misfortune on their village. And again at Samjok, where the house they were building for us had not been finished when we arrived, we were asked to wait before entering it till the piritual influences had been propitiated by music, as otherwise misfortune might ensue.

On the 29th we marched to Samjok. They sent us a message to Toungban, begging not to come till the sun was well up, as they had had so little time to prepare that they were not ready to receive us. So we started later than usual, and dawdled away some time in admiring the view at Nat-than-yit, a village on the Kyendwen, and did not reach Samjok till noon. Even then our shed was not ready, but in about half an hour the band struck up and we entered and made ourselves comfortable. Our accommodation was a large shed about forty feet by twenty, with planks laid down as a floor, with a leaf awning about a hundred feet square in front, and sheds for the guard, servants, and kitchen. The roof of our house was, to be sure, somewhat like a sieve, and the walls rather like a bird-cage; but that was not from want of civil intention, but from want of time to do better; and considering that we were not wanted, and were looked upon more or less in the light of enemies, our treatment was very good—indeed so hospitable that we got more food than we knew what to do with, the Raja sending us a present of that sort every two hours during the day. A band had been sent to enliven us, consisting of a chime of drums, a big drum, pipes, cymbals, and bamboo castanets. The man playing on the chime sat inside a tub-like enclosure of carved wood with his drums in a circle round him—a picture, by the way, of such a band of musicians was printed in the *Illustrated London News* last year. A conjuror also was sent in the evening: one of his tricks was very cleverly done. He held a rupee on the tip of his finger and asked that some one in the crowd should try to catch it. One of our Kuki coolies who was near held out his hand, and the conjuror smacked the rupee into his palm. The Kuki closed his hand, and grasping the finger and money shouted "I have it," and was very much amused and amazed to see the man when he had succeeded in pulling out his finger hold it out with the rupee on it, and to find his hand empty when he opened it. Dancing and singing girls were provided for our entertainment at night. The dancing was posturing, more graceful and lively than that of Indian dancing-girls, and not indecent. The women pinned their dresses down the side, which was necessary, as a Burmese woman's petticoat, though it reaches her heels, is only about four feet broad. The singing was really pretty, a ballad evidently, in two voices, the tune and time changing to suit the verse. It was, I believe, about the universal melody, one verse, which we got the translation of, being apparently a description of a pair of lovers, describing her as the silver tendrilled vine clinging to him, the golden tree. The Raja had wanted to get up a play for us, but could not on account of the death of one and the sickness of another of the actors. The one who died had died of cholera, which had been very bad just before our visit. It appears to me, by the way, that new rice must have something to do with outbreaks of cholera. It invariably appears with the new rice in Sylhet, and has done so here also. The harvest here is just over, and rice is selling at three annas or less a maund. In Mandalay the price, I believe, is a rupee. Two of the Raja's ministers came to confer with Phayre, and to ask us to postpone our return till the day after next, as next day the Raja wished to pay us a visit.

The Raja, or, to give him his proper Burman title, the *Tsáwba*, came at about 11 o'clock. He fired a couple of guns (clay bombs, I suppose, they were) at starting, and then his procession appeared winding along the sand and riverside. Two lictors, armed with sword, rod, and cord, cleared the way. Nine priests, calm and slow, with shaven heads and yellow robes, headed the procession. Then followed men with pennons of white or purple with broad edgings of gold. Then the *Tsáwba* and his younger brother carried on tray-like platforms at the height of men's shoulders. Then the ministers and *pán*-bearers, &c., on either side, followed by sepoys and musicians, five gold umbrellas, two fine elephants, and about a thousand people, men, women and children, all walking except the *Tsáwba* and his brother. They were both very handsomely dressed. He had on a loose crimson velvet coat with hanging sleeves, with collar, cuffs and border about a foot broad of gold, a handsome silk nether garment, and a high white and gold conical cap. The ministers were in white, with white fillets round their heads. The troops were in a uniform of black jackets, red plaid continuation, and red fillets; the sedan-bearers were also dressed uniformly, and all the people were neat and clean; and one could not help noticing how different it was in this to what one sees in Indian processions, where the tagrag and bobtail element is always so very conspicuous. It was altogether a most picturesque procession, the irregularity of its approach along the river bank helping to make it more so, and in this picturesqueness it was very much superior to such processions as one sees at home, which, to my mind, could not hold a candle to it. But in this I may have peculiar ideas, as I can see no beauty, nor anything but dreary absurdity, in a pseudo-military tramp of trades-people with double-poled banners following a town band.

A raised platform had been built and roofed in, under which the priests sat. In front, a scarlet awning was stretched and a carpet laid down with chairs for us and the *Tsáwba*. All his people and ours were collected round. Phayre had a long talk with him and his ministers, the upshot of which was that he asked us to wait for a day for his answer as to whether the surveyors might go into the Angoching hills; every other point he said he must refer to Mandalay. Seeing it from one side only perhaps, and as Phayre told him, he must not be surprised if his territory suffered, and that though we desired to do justice, once we had settled the boundary we would not draw back or reconsider it, as we had acted all through in conformity with the usage of great nations, and the omissions had been entirely on their side. Before leaving, the *Tsáwba* asked to see the sepoys (we had twenty-seven police) go through some exercises, so the *havildar* put them through the manual and platoon, the latter making, I fancy, rather an impression, especially "fire two rounds, front rank kneeling."

The *Tsáwba* is a fine looking man. I noticed that he had peculiarly long untap[illegible] fingers, which made his hand seem wedge-shaped, which perhaps may be an ind[illegible] tion of character explainable by chirosophists. He asked my age, and in return for [illegible] information told us that he was thirty-three, which I have no doubt was correct; but [illegible] looked forty.

In the afternoon we went to see the town. It was a cloudy day in December, so we lost the effect of bright light and full fresh foliage; but even as it was, it was very pretty. About the middle of the town, but more removed from the river, is the *Tsáwba's* house, with a Chinese pagoda-like wooden spire and many gables; to the south and south-west are the spur of a little hill with many pagodas; and the monastery and all, interspersed with magnificent mangoes, cocoanuts, palms, and other trees, and the view of this, with the broad-winding river seen from the monastery hill, is quite charming. The town is a single street on the river bank, and in front there is a strip of sand, with some sheds occupied by people connected with the boats which come to trade. Every place was beautifully clean. I wanted to find a memento of our visit, but there was nothing for sale except pottery, red and unglazed, but very good. It seems to be a speciality of the place, and all the boats at the landing were loading with some of it, and it is used all over the district. It is the only produce of the place I believe. There were half-a-dozen large boats at the place, and there are always some there, either going up or coming down, and in August a number of boats pass down, which have been farther up the river to the Kamti country, trading for turpentine among other things. They go up, I suppose, in the spring and return with the flood at the end of the rains. I was in treaty for an ivory-handled sword, but at the last moment the owner refused to sell it, and I afterwards heard that this was by the *Tsáwba's* order, who had ordered that nothing of the sort should be sold to us, though why I cannot say.

Samjok, which has been visited by only about half-a-dozen Europeans, has a great name in these parts; but it is only a place of sixty houses, with no fortifications, and only about thirty sepoys. There are, I was told, about three hundred houses in the district governed by Samjok, which does not extend across the river, but I think from what I saw that there may be six hundred. It is in a very defensible position, provided the hill to the south of the place were fortified, as it has the broad, deep river to the east, a stream with rotten banks and soft silty bottom to the north, and a great marsh to the west. Whoever holds the hill has the town, but there is no way of getting to the hill from the north, so far as I know, except through the town.

The Kyendwen (pronounced Chindwin) river is a fine stream about 2,000 feet across, just above Samjok, and perhaps 200 feet broader opposite the town. It is said to be fifty feet deep in the channel, and the current here was about a mile an hour. The banks are steep, about twenty feet high, with forest growing to their edges, except where there is cultivation or habitation. It is navigable for large boats (sixty feet long and flat bottomed) for two months' journey farther up, the same journey by land occupying one month.*

All this part of Burma is covered with forest, and though I did not see any good timber on our route there must be some, as the Kyendwen River Steamer Company have purchased the monopoly of the timber trade of this river for Rs. 20,000 a year, and the slabs of teak used for boat building were magnificent. About fifteen to twenty miles east of the Kyendwen is another large river, the Mu, which joins it lower down, along which there seems to be a good deal of cultivation, and where they say ponies are plentiful. Beyond the Mu I saw one or two mountain ranges.

There used to be a good deal of trade between this part of Burma and Manipur, principally of buffaloes, ponies, and lacquer oil. The so-called Manipuri pony was really a north Burma pony, and since the supply has been stopped the number and quality available in Manipur has greatly fallen off and the prices quadrupled For the last four years there has been no trade. A body of Shans surprised the Kungal thana, killed seven Manipuries who were there, and burnt it. Burma would give no reparation, so the passes were closed.

During the evening the Manipuri *subadar* with us brought up a youth, who he said was the son of a Manipuri captive by a Shan mother. He was a handsome young fellow, which at once distinguished him from his Shan companions, for the Shans cannot be called good looking, but the curious thing about him was that he spoke Manipuri fluently. I think it is not generally the case that the father's language is learnt in the mother's country. Another handsome fellow also came to see us, and there was no mistaking his well-cut features and thick curled moustache and whiskers (neither of which are Shan properties) for anything but Hindoo. He was a man from Goruckpore. He asked me if I could help him to get away. On questioning him I found he had been fourteen years in Samjok. He must have been quite a boy when he first came, as he did not look more than eight and twenty. He had, he said, landed at the place, and on the first night of his stay all his belongings were stolen. For eight days, being unable to cook, he chewed raw rice, and then gave in and turned Burman. He had since engaged in several occupations, made money and had it stolen. He at last determined to leave and invested his money in six ponies,

* There is gold in the Kyendwen. Otter skins are laid in the stream at night, dried during the day, and dusted in the evening. A family can collect a tolah in a week in this way. Old women also collect it by washing. Any lumps of gold found are thrown back into the river, for, say they, "If we take the fathers and mothers, we shall not get any more of the youngsters," meaning the small grain.

had been turned back at the Manipur frontier, and three of his beasts were now dead. had not married, as he said, "Where a man's children are his home is," and he wanted is funeral in his own country. I was sorry for him, but could not help him. When the passes are open again, he will get away I hope.

On the 31st we made a long march of twenty-three miles to Morlung, and on the 1st of January, Phayre having gone on to Tammu to visit the Pagan Woon, I returned to the Kungal camp.

There are four routes from Manipur to the Kabu valley, but only two of those, the Inganrok-Kungal and the Imol-morch, could be used by troops, water being scarce on the others. These two also are easier, the Imol being much the easiest of the four. The Kungal and Morch thanas, at the edge of the Kabu valley, are each five marches from Manipur. From Kungal a level path leads by Thanan (12 miles, 6 houses) to Morlung (4 miles, 14 houses) at the foot of the Angoching range. Thence the path of Samjok crosses the range to Toungban (18 miles, 18 houses). The range is about 1,500 feet above the valley. To the west the ascent is steep, to the east the path follows a gently sloping spur the whole way. From Toungban to Samjok (about 5 miles) the road is level. It crosses at one mile the Nalthangit river at Tschdangon (6 houses), and at four miles passes Nalthangit village (30 houses). Between this and Samjok there are two small streams, the path following the river bank. The road from Morch thana joins the road at Morlung, the distance being about thirty-two miles. It passes near Tammu (18 houses), Kondong (8 houses), Mangsa (20 houses), Tap or old Samjok (10 houses), and Monoi (4 houses). There is water on all these routes at moderate distances, and in the dry weather room for camping in the fields near the villages, or, where they are in bearing, in the jungle, which is thin tree forest with little undergrowth. At Nalthangit there is a fine plain, half a mile square. The paths are all fit for laden animals except elephants, but would be so for them with a little improvement. The Nalthangit river was a foot deep when we crossed it. There is no ford at Samjok, and not more than a dozen boats, large and small. Rice was very cheap; but this was probably because there were no buyers, not on account of any very large supply. The whole country, except for small patches of cultivation, grass, or swamp, is covered with forest. This, when we saw it, was of small scattered trees with light undergrowth, principally of a weed called *goldfussia*. Lieutenant Dun, of the Intelligence Department, has made a careful report on the passes between Manipur and Kabu, so I need not describe them. They are included in my map.

As a route for trade the Manipur valley will, I think, be happily exempt; the road from Cachar is excellently made, but it crosses seven ranges, and the hills are tremendous, and those to the east of the valley are nearly as high. The whole journey from Samjok to Cachar, at ordinary rates of travel, would take about twenty-two days. There is some small trade between Samjok and Southern Burma in China silk handkerchiefs and English salt, which underselis the native product. A few of the handkerchiefs find their way to Manipur.

From the 1st to the 4th of January Mr. Ogle and I were engaged in computing and plotting our triangulation. On the 5th I marked out the boundary with Colonel Johnstone, and on the 6th Kungal camp broke up, our boundary work being done.

The demarcation of this part of the Manipur boundary had become necessary for several reasons, the principal being that while no definite line existed the Burmese were able to support some villages of Kukies, whom they had sent, with the intention of annoying Manipur, to settle on lands claimed by Manipur, whence they raided on and enslaved the Manipuri Naga tributaries, and whence they could not be dislodged without the probability of bringing on a war, which, as it would have involved us also, it was the policy of the Government to prevent. The trouble that Manipur has had from these Kukies is a Nemesis on their conduct to them in past time, and would be also to Government should anything more serious come of it. The Kukies originally came from the south-west, and settled in Manipur by invitation of the Raja. Some years ago the chief, while on his way to Manipur to see Colonel McCulloch, who had sent for him, was treacherously murdered by a Manipuri. Government would not interfere, and the Manipuri was not hanged, and the chief's son, now grown up, is a bitter enemy to the Manipuries. They have tried to win him over by kindness and concession, once ransoming his mother, who had been carried off by the Shans, at a heavy price, but he is not to be won. Four years ago he left Manipur territory with all his tribe, and since then has been giving a good deal of trouble.

Since the time when Manipur, much more powerful than now, made six raids upon Burma and carried their arms to the Irawadi, and Burma in retaliation made seven raids on Manipur and slaughtered men, women, children, and cattle indiscriminately, the two peoples have been bitter enemies, and the boundary that keeps them farthest apart is the best for the preserving of peace on the border. This, which is of so much importance to us as well as to them, the boundary, as now laid down, does better than any other line that could be chosen, as for nearly its whole length it follows the bases of the hills or streams in deep gorges in the hills, which are parts of the country avoided by both people; the Naga tributaries of Manipur keeping high on the ridges and spurs for their joom cultivation, and the Burmese keeping away from the hills in the flat plain for their flooded fields of rice. The only hills used as part of the boundary is the Kusom range, north of the Nampagna river. This has always been known as the boundary in that part, and serves very well, as it is not habitable more than half way up, the peaks being of the most extraordinary jaggedness, and more like those in a young lady's fancy sketch than any I have ever seen. The entire boundary, except for

about a mile near Kungal thana, is unmistakeably marked by nature, and therefore req[redacted] neither the trouble nor the expense of marking or maintaining.

From the 6th till my return I was engaged in triangulation and topography. The most southerly point which I visited was Morch thana. This is used as a penal settlement for women who have committed murder. There were about a dozen murderesses in the place, who waited on me with a present of fishes, and among them I am glad to say that there was only one moderately good looking. She had quarrelled with another girl and drowned her. Banishment is the extreme penalty which women suffer in Manipur. For offences less than murder they are cried in the marketplace, and the most severe form of this punishment is awarded to women who go wrong with men out of their caste. They are shaved and hideously painted, and so led naked up and down the marketplace for three days, a drummer going before crying their crime. They also lose their caste. Men are not hanged in Manipur, except for murdering women. For other murders they are nominally banished to a place in the south of the valley, where they are made over to the natives, who kill them. For other serious offences men are banished to the islands in the Logtak lake, where they suffer torment from mosquitoes, which are so numerous, they say, that they can be caught by handfuls.

On the 21st I returned to Manipur, and on the 25th started for Calcutta, my work in the field being finished. During January I observed at four stations and plane-tabled about 600 square miles. The total amount surveyed by me has been 900 square miles. To the end of January Mr. Ogle had finished about 450 square miles. The total area of our survey therefore on that date was about 1,350 square miles, on the half-inch scale. Besides this, I was able to get in on the same scale about 500 square miles of reconnaissance. Mr. Ogle is now continuing, by your orders, the survey in Manipur, and will bring in, I hope, some valuable information.

Extract from a Narrative Report, dated 12th January 1883, *by* J. B. N. Hennessey, Esq., M.A., *Deputy Superintendent, 1st grade, on Surveys in Dardistan and on the Kishanganga.*

There is a tract of country, horse-shoe in shape, belonging to Dardistan, with Chilás about the centre and the Indus bisecting it north and south. This tract is some 45 by 30 miles, and is edged by the territories of Kashmir, along which edge will be found Khanbari Darra, Báriben pass, Gor, Nangá Parbat, and the Indus-Kishanganga water-shed reaching to Kaghán. This horse-shoe could not be surveyed, because the ruler of Chilás refused admittance to surveyors, nor had the surrounding water-sheds been visited, so that the important passes leading across the Chilás horse-shoe were generally unknown. By visiting the water-shed, which is the boundary of Kashmir, not only could the passes be fixed, but as the country must slope from the northern and southern limiting ridges down to the Indus, it was reckoned that a valuable sketch of the horse-shoe itself may be obtained.

Ahmad Ali was despatched to carry out the foregoing plan, with directions to begin at the west end of the south edge of the horse-shoe; but owing to the delay already mentioned, he did not leave Dehra until 26th July. Further delay occurred at Srinagar, due to his own illness and the absence of the Maharaja's dewan, so that the sub-surveyor did not reach his ground and commence work until 15th September; meanwhile the winter snow had begun, and, when standing on Gamukdori pass, his foreground for some 8 or 10 miles presented merely a confused mass of white hills, bare of vegetation and otherwise very like one another. His northern aspect at the next station he visited, Hole Nár pass, was hardly more favourable, and in brief his season's work was hampered by fresh snow and by illness brought on by exposure.

Notwithstanding Ahmad Ali persevered working up the Kel Darra, across the Shochar pass into the Mir Malik Darra and up it to Rattu, and from thence down the Kamri Darra to the Kamri pass, where, with winter well on him, he ceased surveying on 12th November.

Although his field season was unavoidably short, he sketched on the ½ inch about 800 square miles of country, of which some 200 square miles to the north were never sketched before, and the remaining 600 miles had been reconnoitered rather than surveyed, the latter area, on the extreme confines of Kashmir, and part of it *at the time* utterly uninhabited, had not been *visited* by Ahmad Ali's predecessor, who appears to have sketched from a distance of 10 or 12 miles, and in fact not to have crossed even the Kishanganga.

Ahmad Ali, however, actually stood on the Kishanganga-Indus watershed, so that his survey of the 600 miles in question can be relied on; it differs considerably, as may be supposed, from the original reconnaissance. He also fixed three important passes hitherto unknown on this water-shed, viz.—

Gamukdori	...	...	...	13,400 feet
Hole Nár	...	...	...	14,700 „
Bunar	...	...	...	(Not visited)

besides other passes, &c., within Kashmir territory, and acquired experience by which it is likely he could sketch the horse-shoe in question on making a second attempt.

As regards the passes and traffic, it appears that the Babusar pass, on the confines of Kaghán, is the one mostly used, especially for traffic between the Panjab *viâ* Dardistan to Darel Tangir, &c. There is a made road from the south up to Babusar pass, which is

of access. Traffic from Kashmir to the North-West is carried chiefly along (1) the in the Gilgit valley and over the Chonchur pass (some 14,000 feet), which, notwithding its height, is easy to cross; (2) Hatupír pass (10,200 feet), fodder and fuel on ss, but not on camping ground below; (3) Thosho and Mazeno, high (perhaps 17,000 feet) and difficult; (4) Bunar and Hole Nár (14,700 feet), open for laden cattle; (5) Gamukdori (13,400 feet), easy but without forage or fuel—it is commonly used and is fitted for laden cattle; and (6) the Babusar pass, which is the easiest of all. The lines over Babusar and Gamukdori unite at Bushe, a village some ten miles south of Chilás.

Ahmad Ali traversed three darras or valleys, which alone were inhabited, *i.e.* *Kamri Darra*, contains about 12 villages with in all some 80 enclosures, each of which holds all the members of one family, *i.e.* all the sons of one father with their wives and children. By estimation, the population is about 900 to 1,000 souls, who are all of the Bota tribe, and consist of Sunnis as well as Shiah Muhammadans. Each sect contracts marriage only with its own sect of *Botás*: they call their language "Shinai:" it abounds with Hindi and Sanscrit words not difficult to recognize. The men are of moderate height, florid, robust, and powerful; they wear handsome and large reddish-brown beards, which, however, are shaved up to the age of 20 or 25: their dress consists of clothing, all woollen and homespun; the cap is a long bag with the mouth rolled up; on the body is worn a sack reaching down to the ankles, and with long sleeves, and under the sack a pair of trousers, which are loose at the ankles; in addition, a choga, or overcoat, is worn during winter: the feet are generally encased in bags of sheep-skin. Sunnis shave their heads entirely. Shiahs wear all their hair, which hangs in long masses. The men delight in the game of polo, which is played on sturdy galloways; they are also much given to sport, in which they are aided by large hairy dogs. Their arms consist of sword and matchlock, with bows and arrows; the bows are made from prepared strips of the horns of the márkhor: every man wears a knife. As a rule, each man has only one wife, but a second wife is not uncommon.

The women are handsome, and on the whole taller than the men, from whose dress theirs differs chiefly in the cap and trousers; the former is not rolled up, and is decorated along the edge, and the latter are close-fitting at the ankles; the women work equally with the men, excepting in ploughing, which is done exclusively by the latter. The custom of "purdah" is not recognized, and in fact the women are merry, cheerful creatures, and are by no means averse to chat, even with strangers; at the same time they are chaste and circumspect, and adultery is punished, alike with murder, by putting to death. The women wear their hair in a single platted tail at the back with loose masses from the sides of the head.

There is no wine in the country, and in fact there is no fruit, except that called *tút* (mulberry). The people grow "trumba" and "china" (both described as *small* grains), and wheat, cabbage, radish, turnip, and squash. Onion grows wild, and is eaten generally. As the winter approaches, preparations are made for living indoors during the four months beginning with December; fodder and food are collected, and water stored in wells dug within the houses. Notwithstanding the extreme cold prevailing for a portion of the year, old people were not uncommon, of ages professedly from 70 to 90 years, who were yet able to go about without difficulty.

Mir Malik Darra contains only two villages with some 13 enclosures, containing in all about 150 souls. The inhabitants are Botás, as those in Kamri Darra, and are practically identical with the latter. Both Kamri and Mir Malik Darras are well wooded and watered.

Kel Darra was uninhabited until about 12 years back, when it was occupied by people from Kaghán, all Panjabi Paharis, and Sunni Muhammadans. The valley contains but two villages, of which the houses are very scattered; besides that there are numerous temporary dwellings for herdsmen. The permanent houses are some 80 in number, but each house contains only one man and his dependents. In all, the population is about 600 souls: the men commonly have a plurality of wives, not, however, exceeding two as a rule: children abound.

The men are rather tall, strong without being heavy, of a florid complexion, with enormous reddish-brown beards: they all shave their heads, on which they wear black turbans. Their dress consists of loose trousers reaching to the knees, with gaiters lower down, and shoes, and a coat, which has an open slit in front: over the latter a sheet of wool or cotton is wrapped round as occasion may require. Their arms consist of sword and matchlock with a knife.

The women are as tall as the men, fair, and handsome. Their dress consists of shoes, trousers very loose except at ankles, where tight, a "kurta" or sack to the knees, and a sheet over all covering the head. They do not practise "purdah" amongst their own tribe, but in speaking to strangers make some moderate show of hiding the face. The women do not work with the plough, the use of which is left to men exclusively; otherwise they toil equally hard, and can carry heavy loads.

Besides cultivating the land, the people are great herdsmen, having large numbers of cattle: their buffaloes and goats are very large and handsome; but in the whole valley only 3 or 4 horses were seen. The darra is not subject to great cold, and is well watered and wooded; grass is very abundant, and stands the height of a man. There is no fruit whatever. They grow Indian corn (makka), which is the only corn procurable; also squash, beans, and turnips: onions are plentiful in a wild state. Domesticated fowls are common, fat, and of a very large kind. Crime is very uncommon, excepting that adultery is not as rigorously punished by death as elsewhere. The people are exceedingly healthy, and attain to great ages. They are not of a combative nature, and stand in dread of their neighbours.

Memorandum by CAPTAIN HARMAN, *explaining the construction of the map of the route followed by—*

Explorer D— C— S—, from Darjeeling to Shigatze, during 1880.
Explorer G— S— S—, in Nepal, during 1880 and 1881.
Explorer G— M— N—, from Shigatze to Khamba Jong, during 1880.
Also of some routes of former explorers.
Also of some of the results of the surveys by the Darjeeling party during 1879 to 1882.

SCALE 16 MILES = 1 INCH.

THE map was prepared for incorporation with sheet No. 9 (2nd edition), Trans-Frontier Maps, G. T. Survey.

The surveys over Nepal by Mr. W. Robert, of the Darjeeling party, shew that the Tambur river of sheet No. 9 should be placed further east, as also the Tipta La pass, but the town of Dhankuta should be placed further west.

The *fort* of "Ilam" has been fixed. Mr. Robert has also fixed many points on the ridge of the great spur which runs down south-westerly (between the Tambur and Arun rivers) from the Tipta La to Dhankuta. Some of these points seem to fix the position of the Milkia La pass, crossed by explorer No. 9 on his way from Taplang Jong to Chainpur. Mr. Robert's pass is east of the position given on sheet No. 9, but its distance from Mr. Robert's position of Taplang Jong agrees with the corresponding distance on sheet No. 9.

Again, some of the points fixed by Mr. Robert on the ridge of the great spur between the Arun and Dudh-kosi river seem to fix the position of the Chakawa La pass crossed by explorer No. 9 on his way from Chainpur to the Dudh-kosi river. Mr. Robert's position (computed) of the Chakawa La and Milkia La have been maintained, and the intermediate traverse of explorer No. 9 has been fitted in by proportion, with the result that Chainpur Bazar (the starting point of the traverse of G— S— S—) has been *shifted* a little east of the position given on sheet No. 9. Mr. Robert's position of the Chakawa La pass agrees with that given on sheet No. 9. I have taken off sheet No. 9 all the work to west of the Chakawa La pass, and into it have forced in the traverses of explorer G— S— S—. It will be found that the distance of the Milkia La from Taplang Jong on the new map disagrees greatly with that on sheet No. 9, as also the position and length of the traverse from Dhankuta to Taplang Jong; but I do not see how this can be helped, because Mr. Robert has fixed a peak within the angle formed by the Sun Kosi and Tambur rivers at their junction, and the traverse of explorer No. 9 from Megzin Thana (on the Kosi river) to Dhankuta has had to be shifted further west to make it lie correctly with respect to the peak. It is to be noted that the route from Dhankuta to Taplong Jong, followed by explorer No. 9, runs over a great number of spurs, and so is difficult to survey correctly. The whole of Sikkim (British and independent) is taken from surveys of the Darjeeling party; also that portion of Nepal, south of the latitude of the Kang La pass and east of the Tambur river and of Thibet and Bhutan, east of Sikkim, and south of the latitude of the Tankra La pass. Of all places whose latitudes have been observed by the explorers, the same latitudes are given on the new map as are shewn on sheet No. 9. Dr. Hooker's routes about the valleys at the head of the Tambur river have been carefully considered, and the position assigned to Tashichoding is near to that given by him. The position of "Khamba Jong" was determined by consideration of the traverse of explorer I—, from Giaogong to Khamba Jong, and of the traverse of explorer D— C— S— from Khamba Jong to the Donkia pass, together with information obtained in Sikkim. The reasons for shifting Shigatze on to longitude 88°54′ are given in my memorandum on the longitude of Shigatze. In consequence of the shift given to Shigatze, the position of the traverse from Katmandu to Shigatze *viâ* the Bhutiakosi and Dingri and Shakia Jong has been altered by proportion.

Memorandum by CAPTAIN HARMAN *on the Longitude of Shigatze.*

IN the annual report on the operations of the Great Trigonometrical Survey of India, 1866-67, Captain Montgomerie, R.E., assigned to Shigatze the longitude 88°48′. He deduced it from Turner's record of the route he followed in 1783 from Tassisudon (in Bhutan) to Giangze Jong (in Thibet). Turner's route places Giangze Jong in longitude 89°31′: thus by the traverse of Pandit Nain Sing from Giangze to Shigatze the latter place falls on longitude 88°48′, and by Nain Sing's traverse from Giangze to Lhasa the latter place falls on longitude 90°59′43″.

In the annual report for 1871, Major Montgomerie gave a map to illustrate the routes followed by explorer No. 9, and on this map Shigatze is placed in longitude 88°40′, such being the mean value of Shigatze as derived from the several traverses between Katmandu and Shigatze. But in the memoir accompanying the map he states that in future maps Shigatze must be placed in longitude 88°47′, being the value derived from the traverse from Darjeeling to Shigatze *viâ* the Tipta La and Chota Tapu. This traverse runs north and south; Darjeeling being in longitude 88°19′. In the confidential report by Captain Trotter, R.E., on the explorations in Thibet during 1873, 1874, and 1875, he assigns to Lhasa the longitude 91°5′30″, deriving it from a traverse made by Pandit Nain Sing from Lhasa to Odalguri in Assam. Consequently Shigatze would be placed on

[illegible]ude 88°54′ and Giangze Jong on 89°37′ (but on Trotter's map Shigatze is shewn [illegible]gitude 88° 47′).

Now, according to the map illustrating the routes followed by explorer No. 9, [illegible]gatze is placed on longitude 88° 40′ and the Tipta La pass on 87°48′30″. According to the recent observations of Mr. W. Robert, of the Darjeeling Survey party, the Tipta La pass is on longitude 87°53′30″; consequently the whole traverse from Darjeeling *vid* the Tipta La to Shigatze must be shifted in longitude, and thus Shigatze falls on longitude 88°54′, which is agreeable with the value derived from Trotter's longitude of the city of Lhasa.

Since the exploration of Pandit Nain Sing from Lhasa to Odulguri, three explorers have traversed between the fort of Khamba Jong (a few miles north of the north frontier of Sikkim) and Shigatze. The approximate position of Khamba Jong is latitude 28°16′ and longitude 88°33′.

The annual report of the Survey Department for 1878-79 gives a map illustrating the route traversed in 1875-76 by the first explorer, known as explorer L—. His traverse from Khamba Jong to Shigatze has been computed, and it gives to Shigatze the longitude of 88°57′.

The second explorer guessed his distances, and the paced distances of the third explorer are doubtful; yet both traverses result in making Shigatze bear 22° east of north from Khamba Jong, and this direction places Shigatze on longitude 89°. Again, taking the latest value of Phari as on longitude 89°11′, the explorer L—'s traverse from Giangze to Phari places Gianzge on longitude 89°38′, and consequently, according to Pandit Nain Sing's traverse from Giangze to Shigatze, Shigatze falls on longitude 88°54′, a value agreeable with that derived from Trotter's longitude of Lhasa.

The traverses of the three explorers from Khamba Jong to Shigatze are not very reliable.

I have adopted the longitude 88°54′ as the most probable value of Shigatze.

Extract from the Narrative Report, dated 26th October 1882, *of* Major M. W. Rogers, R.E., *in charge Tidal and Leveling Operations.*

EVALUATION OF TIDAL CONSTANTS.

The values of the several tidal constants which have been determined for various ports, from the harmonic analysis of all the observations which have been taken during the past year, will now be given.

The tidal constants are divided, as usual, into two groups—one composed of the short-period tides, the duration of which in no case exceeds 24 hours; the other of long-period tides, whose duration ranges from a fortnight to a year.

In the harmonic theory of the tides the principal constituents of the short-period tides are represented by fictitious stars, moving in circular orbits at certain known velocities—the arguments of motion—in the plane of the Equator. They are usually indicated by the letters S, M, O, K, &c. Each of these is, in its turn, composed of a number of tidal constituents, also moving in circular orbits, but with different velocities, which are mutually related, those of the second and subsequent constituents being twice, thrice, or some integral multiple of the first. Their periods are determined in the following manner. When the revolution of the fictitious stars is performed in, or about, 24 hours, the primary period is the one corresponding to the argument of motion of the star; when it is performed in, or about, 12 hours, the primary period corresponds to twice the argument of the motion of the star; the subsequent periods are fractions of the primary, corresponding to the multiples of the velocity. The tidal constituents after the first are sometimes called semi-diurnal, ter-diurnal, quarter-diurnal, and so on, and the smaller of these are usually called *overtides*.

Every tidal constant is expressed numerically by two constants, viz. R and E. R denotes the linear value of the amplitude, viz. the semi-diameter of the orbit, which is equal to half the range between the highest and lowest levels of the constituents; E denotes the angular value of the "epoch;" it may be defined to the number of $\frac{1}{360}$ part of the period, or number of degrees of the orbit, which any tidal constituent has still to execute from the instant when the fictitious star crosses the meridian of the place of observation to the instant when the constituent reaches its maximum.

The constants R and E of the tidal constituents are respectively distinguished by the subscripts 1, 2, 3, representing the relations of their periods to that of the primary period.

Three only of the fictitious stars, viz. S, M, and K, have more than one constituent of sensible magnitude. The constituent which causes any fictitious star to produce its greatest effect on the sea-level is rarely the first, and more frequently the second. The greatest effect of any single star is invariably produced by R_2 of M; afterwards usually by R_2 of S, and R_2 of K, to the last of which the phenomenon of *Diurnal Inequality*, which is so marked a feature in Indian tides, is chiefly due. The first significant constituent of M S is of the fourth period amplitude, R_4.

The first constant in the table of constants for each port is A_0, which signifies height of the mean level of the sea above the level corresponding to the zero of the gau

[*It may be here said once for all that the values of the linear quantities A and R through these tables are invariably expressed in English feet.*]

VALUES OF THE TIDAL CONSTANTS AT ADEN, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Aden :—

Short Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	5·784	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·117	0·056	0·080	1·223	0·375	0·114	0·163	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	151·17	172·72	320·38	119·38	305·47	147·71	316·44	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·033	1·535	.....	0·203	.....	.....	.....	0·078	0·415	0·020	0·133	0·052	0·005	0·057	...	0·021
ϵ_2	231·51	229·80	.....	226·11	.....	.....	.....	44·05	227·51	119·02	196·22	190·70	161·70	2·24	...	102·72
R_3	.....	0·020	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	211·63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·003	0·000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·020	...
ϵ_4	256·65	329·25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	105·78	...
R_6	0·001	0·001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	190·71	273·42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·001	0·001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	233·00	40·01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}075$ $\epsilon = 347°{\cdot}81$
„ fortnightly „	...	...	$R = 0{\cdot}042$ $\epsilon = 7°{\cdot}32$
Luni-solar „ „	...	...	$R = 0{\cdot}015$ $\epsilon = 297°{\cdot}62$
Solar annual „	...	...	$R = 0{\cdot}402$ $\epsilon = 358°{\cdot}03$
„ semi-annual „	...	...	$R = 0{\cdot}109$ $\epsilon = 160°{\cdot}57$

The mean level of the sea (A_0) is slightly higher than in 1879-80, and almost exactly a mean between the values obtained for the two last years.

The main lunar tide, R_2 of M, is the same as obtained last year, as is also the main solar tide, the epochs in both cases agreeing well with those of the previous years.

The amplitudes and epochs of all the tidal constituents agree well with those obtained last year, both for the short-period and the long-period tides.

The proportion between the two main tides, R_2 of S and R_2 of M, is the same as last year, which is but slightly less than the value given by theory, being 0·446 against 0·476.

The proportion of the smaller lunar elliptic semi-diurnal tide (L) to the main lunar tide is very nearly twice what theory would assign, whereas last year it was only about half the theoretical value, and the year before it almost agreed with it.

The proportion between the larger lunar elliptical semi-diurnal tide (N) and the main lunar tide is identically the same as was found last year, being one-third greater than the theoretical value.

The proportion of the evectional semi-diurnal tide (λ) to the main tide is very slightly greater than it was last year, and is nearly double the theoretical proportion.

The other evectional tide (ν) is about $\frac{1}{11}$th the main tide, and is slightly less than last year; but still more than double as great as the theoretical value.

The variational tide (μ) has the same proportion to the main tide as has been found in the two previous years, more than double the theoretical value.

The solar elliptic semi-diurnal tides, R and T, have been deduced for the first time this year (two years' observations being necessary). The smaller component, R, agrees exactly with the theoretical proportion, whilst the larger, T, is about 25 per cent too large.

The luni-solar declinational semi-diurnal tide, R_2 of K, is less in proportion to the tide than has previously been found, and is very near the theoretical value, being against 0·127. The large proportion which the diurnal components bear to the main tide, which is the chief peculiarity at Aden, is again evident from the analysis of this year's observations.

The proportion of the solar diurnal tide, R_1 of S, is considerably larger than has been before obtained here, and very nearly equals the values obtained at Beypore and Paumben, being 7 per cent of the main tide.

The main diurnal tide, R_1 of K, is nearly the same in amplitude as in 1877-78, and but slightly less than that for 1879-80; it bears the same immense proportion to the main lunar tide, being 85 per cent of it.

The solar diurnal tide (P) is about 24 per cent of the main tide, which is much about the same as has been found in the previous years, and is greater than in any other Indian port.

The proportions of the diurnal tides, O, J, and Q, to the main tide, agree well with those found in the previous years. O is a little less than before, but is still 44 per cent of the main tide.

The proportion between P and O is within the theoretical limits; that between J and Q is again higher than the previous year, and much higher than theory gives. O to K is slightly less than the last year, and less than minimum proportion given by theory.

With regard to the long period tides. The proportions to the main tide (except in the case of the lunar monthly and lunar fortnightly) are nearly the same as last year. The lunar monthly is double the value obtained in the previous year, whilst the lunar fortnightly is one-third less.

The epoch of the solar annual agrees well with last year, but the solar semi-annual is a month later than last year.

VALUES OF THE TIDAL CONSTANTS AT ADEN, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Aden:—

Short-Period Tides

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	μ	*R*	*T*	*MS*	2*SM*
A_0	5·814	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·093	0·088	0·627	1·275	0·339	0·051	0·130	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	161·49	106·88	315·83	116·75	303·45	130·25	322·40	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·704	1·856	.....	0·176	.....	.....	.....	0·052	0·420	0·038	0·060	0·074	...	...	...	0·021
ϵ_2	246·32	225·48	.....	224·67	.....	.....	.....	13·43	221·06	23·39	167·82	178·25	...	...	...	115·85
R_3	.....	0·018	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	198·29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·006	0·007	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·002	...
ϵ_4	274·76	313·82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	164·15	...
R_6	0·004	0·004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	209·58	19·60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·001	0·004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	323·01	324·43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	$R = 0·026$	$\epsilon = 324°·129$
,, fortnightly ,,	$R = 0·042$	$\epsilon = 1°·90$
Luni-solar ,, ,,	$R = 0·016$	$\epsilon = 100°·37$
Solar annual ,,	$R = 0·353$	$\epsilon = 1°·62$
,, semi-annual ,,	$R = 0·093$	$\epsilon = 150°·93$

The mean level of the sea (A_0) is slightly higher than has been obtained in preceding years.

The amplitudes of the main lunar and solar tides are almost the same as the previous year's, and therefore the proportion between them is identical with what had been found before. This is rather less than the theoretical value, being 0·444 against 0·476.

With regard to the lunar elliptic semi-diurnal tides, the smaller (L) has a proportion to the main tide slightly less than theory gives, ·020 against ·027; and this value is just the mean between the values of the two first years, but is very much less than that of the preceding year.

The proportion between the larger component (N) and the main tide is rather less than has yet been found, but is still one-third greater than is given by theory.

The proportion of the evectional semi-diurnal tide (λ) to the main tide is higher than has yet been found at Aden, being more than three times greater than the theoretical value, whilst the proportion of the other evectional tide (ν) agrees exactly with theory.

The variational tide (μ) is 5 per cent of the main tide, which agrees with the values from former years, but is double the theoretical value.

The luni-solar declinational semi-diurnal tide (R_2 of K) is rather less in proportion to the main tide than has yet been found here, and is slightly in defect of the theoretical value.

The proportion of the luni-solar compound semi-diurnal tide to the main tide is the same as was found in the two previous years.

The high proportion of the diurnal tides to the main tide at Aden is again shown this year. The chief of these, the luni-solar declinational tide (R_1 of K), is 80 per cent of the main tide. The solar declinational diurnal tide (P) is 25 per cent, and the lunar declinational diurnal (O) 40 per cent of the main tide. These proportions are the greatest found at any Indian port, Beypore having the nearest approach to such high values.

The proportions between P and O, J and Q, and O and K, are very much the same as previously obtained. The first two are greater than theory gives, and the third less.

The lunar and solar over-tides agree with the values of previous years, and are all small.

With regard to the long-period tides, their amplitudes and epochs agree fairly well with the results of preceding years. The solar-annual and semi-annual are slightly less than previously obtained, but call for no special comment.

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1879-80.

The following are the amplitudes and epochs deduced from the 1879-80 observations at Kurrachee:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	7·308	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_1	0·093	0·062	0·707	1·307	0·330	0·110	0·109	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_1	161·33	237·30	326·61	129·60	315·06	142·27	323·97	.....	.....	.....	.....	.....	.....	.....	...	.....
R_2	0·267	2·525	.....	0·316	.....	.....	.....	0·077	0·190	0·019	0·088	0·075	.....	.....	...	0·018
ϵ_2	324·73	294·25	.....	308·22	.....	.....	.....	141·48	278·11	213·39	320·91	245·17	.....	.....	...	159·68
R_3	.....	0·041	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_3	.....	316·77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_4	0·005	0·026	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·031	.....
ϵ_4	63·09	2·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	335·45	.....
R6	0·005	0·033	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_6	324·69	213·06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_8	0·002	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_8	222·71	11·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·038$ $\epsilon = 25°·61$
„ fortnightly „	...	...	$R = 0·035$ $\epsilon = 307°·16$
Luni-solar „	„	...	...	$R = 0·030$ $\epsilon = 320°·17$
Solar annual	„	...	...	$R = 0·042$ $\epsilon = 86°·49$
„ semi-annual	„	...	...	$R = 0·165$ $\epsilon = 170°·97$

[illegible] value of mean sea-level (A_0) is the highest yet obtained, except in 1878-79, which, [illegible], having been specially treated to correct for alterations of zero, cannot be considered [illegible]ve quite the same weight.

The amplitudes and epochs of the main solar and lunar tides agree well with the values of previous years. The proportion between them is likewise nearly the same as before, but is considerably less than the theoretical value, being 0·379 against 0·476.

With regard to the lunar elliptic semi-diurnal tides, the smaller (L) has a proportional value double what was found in the preceding year, and agreeing very nearly with the theoretical proportion, which on the whole is nearly approached at Kurrachee.

The larger component has a proportional value not far from the mean value of former years, and rather greater than is given by theory.

With reference to the lunar perturbational tides, the smaller evectional tide (λ) has nearly exactly the theoretical proportion to the main tide: previous years have generally given a larger value.

The larger component (ν) is also almost identical with the theoretical value, being smaller than has been generally found here.

The variational tide (μ) has a proportional value of ·030; theory gives ·022. The general mean of the previous years is ·026.

The luni-solar declinational semi-diurnal tide (R_2 of K) agrees very well with the general value at Kurrachee, and has nearly the theoretical proportion to the main tide.

The diurnal tides call for no special mention; they agree very well with the values obtained in previous years.

The same may be said of the over-tides of S and M.

With regard to the long-period tides, the lunar tides call for no special mention; they agree well with the general mean value of former years.

The solar annual is, however, abnormally small, being hardly 2 per cent of the main tide. Its epoch is the 18th June, a month earlier than in 1877-78. The epochs of this tide at Kurrachee have been variable.

The semi-annual tide has a proportional value about equal to the mean of former years; its epochs, which occur on the 18th June and December, are also unsettled at this port.

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Kurrachee:—

Short-Period Tides.

	S	M	O	K	P	J	Q	L	N	λ	ν	μ	R	T	MS	2SM
A_0	7·267	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·135	0·067	0·646	1·264	0·206	0·068	0·106	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	63·64	107·83	326·90	127·95	318·51	183·19	331·43	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·969	2·536	.....	0·421	.....	.....	.....	0·148	0·581	0·020	0·169	0·037	0·040	0·094	...	0·031
ϵ_2	323·55	292·58	.....	303·99	.....	.....	.....	120·87	273·56	139·74	311·43	278·35	58·04	49·22	...	122·35
R_3	.....	0·039	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	316·19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·006	0·026	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·028	...
ϵ_4	31·43	357·37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	315·35	...
R_5	0·006	0·052	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_5	291·63	202·19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	11·31	332·25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	... ...	$R = 0·036$	$\epsilon = 131°·23$
„ fortnightly „	... ...	$R = 0·021$	$\epsilon = 47°·45$
Luni-solar „ „	... ...	$R = 0·018$	$\epsilon = 304°·50$
Solar annual „	... ...	$R = 0·102$	$\epsilon = 101°·51$
„ semi-annual „	... ...	$R = 0·139$	$\epsilon = 191°·73$

The value of mean sea-level (A_0) is slightly less than last year, and agrees [redacted] with the general mean of previous years.

The main solar and lunar tides are slightly higher than before found, but they [redacted] well both in amplitudes and epochs with previous values.

The proportion of the main solar to the main lunar tide is 0·382, which is quite accordant with former values, and is considerably less than the value given by theory, 0·476.

The smaller lunar elliptic semi-diurnal tide (L) has a proportion to the main tide nearly double that of last year, and much larger than the usual proportion at Kurrachee, which approaches nearly to the theoretical value.

The proportion of the larger component (N) to the main tide is nearly the same as last year, and agrees well with the mean of preceding years, but is rather greater than the theoretical proportion.

With regard to the evectional tides, the smaller (λ) has the same proportion to the main tide as was found last year, and which is nearly the theoretical value.

The larger (ν) is nearly double what was found last year, when its proportional value nearly agreed with what theory assigns.

The variation tide (μ) has only half the proportional value which was obtained last year, and is considerably under the theoretical value.

The solar elliptic semi-diurnal tides are calculated this year. The smaller one (R) has a proportional value four times as great as theory assigns. This is about the mean value of this tide at Kurrachee.

The larger component (T) is about 25 per cent greater than the theoretical proportional value.

The luni-solar declinational semi-diurnal tide is larger than has ever yet been found at this port. Its proportional value is 0·166 : theory gives 0·127.

With regard to the diurnal tides, the largest (R_1 of K) is rather smaller this year than in general. R_1 of S is larger, amounting to 5 per cent of the main lunar tide.

The lunar diurnal tide on the contrary has a smaller proportion than usual. The other diurnal tides have this year smaller proportional values than the mean of former years.

The over-tides of S and M are much the same as in previous years. The over-tide, R_6 of M, at Kurrachee is double the quarter diurnal tide, a peculiarity which in the Indian tides only occurs at one other place, Elephant Point.

With regard to the long-period tides. The lunar tides are rather smaller than the mean of previous years. The solar annual tide this year is 4 per cent of the main lunar tide; last year it was hardly 2 per cent. The value of this tide has fluctuated greatly at Kurrachee, as also has the epoch, which this year is about 15 days later than last year, when the maximum occurred about the middle of June.

The solar semi-annual tide is slightly less than last year, and agrees well with the general mean value. Its times of maximum occur about ten days later this year than the last, *i.e.* about the end of June and December.

VALUES OF THE TIDAL CONSTANTS, BOMBAY, 1880.

The following are the amplitudes and epochs deduced from the 1880 observations at Bombay:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	10·157	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_1	0·068	0·020	0·091	1·453	0·405	0·154	0·166	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_1	184·12	223·58	227·81	126·37	313·53	139·14	333·01	.....	.....	.....	.....	.....	.....	.....	...	...
R_2	1·627	4·049	.....	0·448	.....	.....	.....	0·129	0·267	0·050	0·078	0·212	.....	.....	...	0·048
ϵ_2	3·61	332·59	.....	337·06	.....	.....	.....	141·93	343·90	333·18	266·39	309·76	.....	.....	...	114·43
R_3	.....	0·068	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_3	.....	22·14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_4	0·013	0·119	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·125	...
ϵ_4	253·26	316·23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	29·60	...
R_6	0·004	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	...
ϵ_6	140·39	72·52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_8	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_8	151·39	304·34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...

Long-Period Tides.

Lunar monthly	tide	...	...	$R = 0{\cdot}041$ $\epsilon = 86°{\cdot}07$
,, fortnightly	,,	...	...	$R = 0{\cdot}059$ $\epsilon = 337°{\cdot}84$
Luni-solar ,,	,,	...	...	$R = 0{\cdot}042$ $\epsilon = 186°{\cdot}09$
Solar annual	,,	...	...	$R = 0{\cdot}173$ $\epsilon = 312°{\cdot}56$
,, semi-annual	,,	...	...	$R = 0{\cdot}071$ $\epsilon = 162°{\cdot}31$

The results of the analysis of this year's observations differ but slightly from those which have been obtained from the reductions of former years, and do not call for any lengthened comment.

The value of A_0, mean level of the sea, is almost identical with that obtained last year, 80·187 instead of 80·184, above Town Hall datum; the mean value, as far as yet obtained, being 80·212 feet.

The amplitude of the main lunar tide (R_2 of S) is the largest yet obtained, being 4·05, against 3·98 in 1879 and 3·89 in 1878; the main solar tide being nearly exactly the mean of the two preceding years.

The proportion between the two main tides is slightly smaller than has yet been obtained, being 0·402; the theoretical value being 0·476.

The epochs in both cases agree well with previous years.

The smaller component (L) of the lunar elliptic tide has a proportion to the main tide much greater than has yet been obtained, being ·039, the previous year having been only ·014. The theoretical value is ·027. For the larger component (N) the proportion agrees very well with the values in former years, and is about 25 per cent greater than the theoretical value.

The perturbation tides, with the exception of ν, agree fairly in their proportions to the main tide with the values of former years. The proportion of ν approaches nearest to that obtained in 1876-77, but is not more than one-third of the value of the last two years.

The luni-solar compound declinational tide (R_2 of K) and the luni-solar compound semi-diurnal (2 SM) are fairly accordant with previous values.

The values of the diurnal tides agree well with what has been found in former years, the principal one (R_1 of K) being 35 per cent of the main tide, which is slightly less than the values previously obtained.

The proportion of the solar and lunar declinational tides, P and O, is ·59 to 1·0, which is about the value already obtained here; theory giving from ·391 : 1 to ·574 : 1.

The proportion between the two lunar elliptic tides, J and Q, is 1 to 1·25, which agrees with the value obtained in 1876; theory giving about 1 to 2·4.

The proportions of the over-tides of S and M are nearly identically the same as found in former years, as is also the proportion of the quarter diurnal luni-solar tide (MS) to the combined lunar and solar semi-diurnal tides, viz. ·022.

The proportion between the lunar ter-diurnal and the lunar semi-diurnal tide is ·017, which is almost precisely the value of former years.

With regard to the long-period tides, the reduction of this year's observations gives in several cases values diverging, both in amplitude and epoch, from those already obtained.

The solar annual has a value of 0·173, against one in 1879 of 0·137 and in 1878 of 0·254. Its epoch agrees within about 15 days with that of 1879, and more nearly with that of 1876, but differs entirely from that of 1878. From the results of 1876, 1879, and 1880, the date of maximum effect seems to be early in February, whilst 1878 gives the middle of August.

With reference to the solar semi-annual tide, the amplitude is nearly the same as in 1878, and not much more than half the value obtained in 1879. The epoch differs considerably from that found in previous years. The maxima would appear to be about the 9th June and 9th December, agreeing most closely with the 1876 values.

The lunar fortnightly and lunar monthly tides agree fairly in amplitude with the two previous years.

The luni-solar fortnightly tide is nearly three times as large as last year, but is nearly a mean between the values of 1876 and 1878.

VALUES OF THE TIDAL CONSTANTS, BOMBAY, 1881.

The following are the amplitudes and epochs deduced from the 1881 observati[illegible] Bombay:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	10·248	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·074	0·099	0·634	1·381	0·403	0·121	0·120	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	178·60	133·31	328·47	126·24	312·23	165·07	326·82	.....	.....	.....	.....	.....	...	...	...	...
R_2	1·618	4·095	.....	0·410	.....	.....	.....	0·006	0·263	0·013	0·122	0·185	0·037	0·256	...	0·036
ϵ_2	3·33	328·58	.....	334·91	.....	.....	.....	110·78	312·61	20·46	0·70	296·90	5·90	81·55	...	111·32
R_3	.....	0·056	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	7·28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·011	0·128	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·126	...
ϵ_4	314·62	319·35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	23·36	...
R_6	0·005	0·017	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	160·35	106·63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	69·44	4·65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·048$ $\epsilon = 55°·55$
„ fortnightly „	...	...	$R = 0·028$ $\epsilon = 226°·38$
Luni-solar „	„	...	... $R = 0·019^{6}$ $\epsilon = 335°·66$
Solar annual	„	...	... $R = 0·188$ $\epsilon = 316°·59$
„ semi-annual	„	...	... $R = 0·204$ $\epsilon = 232°·34$

Analysing these observations, they will be found to give results differing but slightly from those obtained by the reductions of the observation in previous years.

A_0, the mean level of the sea, is found by this year's observations to be 80·248 above the Town Hall datum, which is ·06 feet higher than last year's value, and about the same amount higher than the mean of the four preceding years.

The amplitude of the main lunar tide (R_2 of M) is about ¼ inch greater than the result of last year, and is the largest yet obtained; while the amplitude of the main solar tide is slightly less than last year, and agrees very well with the mean of the previous years.

The main solar tide is only 0·395 of the main lunar, which is the smallest proportion yet found at Bombay, where, however, the value has always been less than the theoretical one, 0·476.

The proportion of the smaller component of the lunar elliptic semi-diurnal tide (L) to the main lunar tide is ·023, which is slightly less than the theoretical one, ·027, but agrees with it much more closely than has been found in any previous year save 1876.

The larger lunar elliptic semi-diurnal (N) agrees very well with the results of former years, being about 24 per cent of the main lunar tide.

The evection and variation tides λ, ν, and μ bear about the same proportion to the main tides as had been found in previous years, λ being rather smaller, whilst the proportion of ν is about mean value.

With regard to the solar elliptic tides the smaller (R) is rather less than the value previously obtained, and its proportion to the main lunar tide is slightly nearer the theoretical value, but still twice as great.

The larger tide (T) is three times greater than its previous value, and its proportion to the main tide of M is more than twice as great as the value given by theory.

The luni-solar declinational semi-diurnal tide (R_2 of K) has a value slightly less than has been yet obtained, and its proportion to the main tide is less than theory assigns, ·100 against ·127; in this agreeing with the last two years, the proportion in 1877 and 1878 being greater than the theoretical value.

The luni-solar compound semi-diurnal tide (2SM) agrees well with previous years.

The proportions of the over-tides of S and M to the main lunar tide agree almost exactly with the previous values.

The proportion of the ter-diurnal lunar tide to its main tide slightly less than has been found in the previous years.

The whole of the diurnal tides agree well in value with the values obtained last year, and their proportion to the main lunar tide is very nearly a mean of the values previously found.

The proportion of the solar declinational tide (P) to the lunar declinational (O) is about 1 : 1·57, which is greater than in any previous year. The theoretical proportion is from 1 : 1·74 to 1 : 2·56.

The proportion between the two lunar elliptic tides J and Q is 1 1·07, being much the largest yet obtained at Bombay. Theory gives the proportion about 1:: 2·4.

The quarter diurnal luni-solar tide (MS) bears precisely the same proportion to the combined lunar and solar semi-diurnal tides as it did in four of the five previous years, viz. ·022; the year 1879 giving ·024.

With regard to the long-period tides, the solar annual has an amplitude a little greater than last year, and an epoch about four days later, agreeing nearly exactly with the value obtained in 1876.

Looking at the five years' values which we have obtained, it would seem that the value, both for amplitude and epoch, obtained in 1878 was abnormal; the other four years are consistent in fixing the dates of the maxima as being in the first half of February. The 1878 values gave the date as the 17th July, and the amplitude as 25 per cent greater than even this year's value, which is the highest of the other four years.

The solar semi-annual gives values, both of amplitude and epoch, divergent from those already obtained. Its amplitude, 0·201 feet, is three times as great as last year's value, ·071, and one-fifth greater than the largest previous value (·163 in 1877). Its epoch is nearly the same as in 1879, but differs from all other years.

The lunar fortnighly agrees fairly in the amplitude with the values of the last two years, but the amplitudes of the other two lunar tides differ greatly from previous values.

VALUES OF THE TIDAL CONSTANTS, KARWAR, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Karwar:—

Short-Period Tides.

	S	M	O	K	P	J	Q	L	N	λ	ν	μ	R	T	MS	2SM
A_0	5·564	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·055	0·052	0·522	1·031	0·252	0·030	0·134	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	156·16	189·55	329·21	125·95	312·59	148·09	354·49	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·621	1·758	.....	0·169	.....	.....	.....	0·073	0·412	0·032	0·122	0·046	...	...	...	0·004
ϵ_2	333·98	298·41	.....	3·09·39	.....	.....	.....	132·53	280·33	206·51	258·46	255·73	...	...	....	16·72
R_3	.....	0·018	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	272·09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·016	0·054	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·021	...
ϵ_4	94·37	7·21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	58·59	...
R_6	0·004	0·013	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	82·24	270·70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·000	0·004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	296·57	0·22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·048$ $\epsilon = 99°·91$
„ fortnightly „	....	...	$R = 0·036$ $\epsilon = 322°·54$
Luni-solar „	„	...	...	$R = 0·021$ $\epsilon = 224°·02$
Solar annual	„	...	...	$R = 0·491$ $\epsilon = 302°·72$
„ semi-annual	„	...	...	$R = 0·128$ $\epsilon = 191°·21$

The value of (A_0), mean level of the sea, is very slightly higher than in the preceding year, being 5·564 against 5·541 for 1879-80. The mean of the three years' observation gives 5·585.

The value of the main lunar tide (R_2 of M) is slightly greater in amplitude than in either of the foregoing years. The epoch agrees well with what was previously found.

The value of the main solar tide (R_2 of S) is nearly the same, both in amplitude and epoch, as in the two preceding years.

The proportion between the two main tides, which was 0·368 and 0·375 in the two last years, is 0·354 this year—all smaller than the theoretical value, though agreeing *inter se*.

The proportions of the lunar elliptic semi-diurnal tides to the main tide are slightly greater for L than in the previous years, and considerably above the theoretical value. For N the proportion of the former years is slightly diminished, but it also is greater than theory gives.

The evectional semi-diurnal tide (λ) differs both in amplitude and epoch from either of the preceding years, and is greater than theory gives. It is ·018 of the main tide; the theoretical value being ·007.

The proportion of the other evectional tide (ν) to the main tide is nearly the same as last year, and about twice the theoretical value.

The variation semi-diurnal tide (μ) has nearly the theoretical value, it being ·026 of the main tide; theory giving ·022.

The semi-diurnal component of the luni-solar declinational tide (R_2 of K) has a smaller value than yet found at this port, and its proportion to the main tide is considerably less than has been found in the previous years, when it had nearly the theoretical value.

The proportion of the luni-solar compound semi-diurnal tide to the main tide is the same as last year, and is the smallest that has been yet obtained at any Indian port; the next smallest being at Beypore and Vizagapatam.

The chief diurnal tide (R_1 of K) bears a proportion to the main tide of ·588 to 1, which is about a mean between Bombay, ·369 to 1, and Beypore, ·794 to 1, and is much the same as is found at Kurrachee.

The solar diurnal tide (R_1 of S) is about $\frac{1}{4}$th of its principal component, being about the same proportion as obtains at Bombay and Kurrachee.

The proportion of P to O is again greater than the previous years, but all these values are within the theoretical limits.

The proportion of J to Q (0·672) is again greater than in 1879-80 (0·584) and 1878-79, when it was 0·413; these values are all in excess of the maximum theoretical limit, 0·417.

The proportion of O to K is nearly the same (0·506) as was found in the two previous years (0·518 and 0·517), but all much less than the minimum proportion given by theory (0·657).

The proportions of the over-tides of S and M are all small, and agree fairly well with those of the previous years, except the solar quarter-diurnal tide (R_4 of M), which is twice as great.

The Helmholtz tide (MS) is ·009 of the main lunar tide, the same value as was obtained in 1878-79.

With regard to the long-period tides, the lunar monthly and luni-solar fortnightly agree with previous values; but the lunar fortnightly bears only about half the proportion to the main tide that it has borne in previous years.

The solar annual and semi-annual again show a considerable increase, these values being three times as large as those found for 1878-79.

The epochs of both the solar annual and semi-annual agree well with last year's dates, being about four days earlier.

VALUES OF THE TIDAL CONSTANTS, KARWAR, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Karwar:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2 *SM*
A_0	5·515	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·052	0·013	0·479	0·269	0·287	0·063	0·008	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	164·75	121·81	329·33	125·30	310·86	144·06	339·17	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·616	1·772	.....	0·164	.....	.....	.....	0·057	0·404	0·021	0·058	0·051	0·009	0·075	...	0·007
ϵ_2	333·29	298·82	.....	316·04	.....	.....	.....	95·79	279·11	158·89	230·37	240·15	330·73	20·36	...	208·50
R_3	.....	0,012	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	..
ϵ_3	.....	260·62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_3	0·011	0·060	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·029	...
ϵ_4	109·55	12·28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	57·74	...
R_6	0·006	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	51·34	277·71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	282·53	56·19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}045$ $\epsilon = 0°{\cdot}47$
,, fortnightly ,,	...	...	$R = 0{\cdot}035$ $\epsilon = 350°{\cdot}49$
Luni-solar ,, ,,	...	...	$R = 0{\cdot}009$ $\epsilon = 91°{\cdot}27$
Solar annual ,,	...	...	$R = 0{\cdot}383$ $\epsilon = 302°{\cdot}56$
,, semi-annual ,,	...	...	$R = 0\,053$ $\epsilon = 224°{\cdot}01$

The value of A_0, the mean level of the sea, above the zero of the gauge is slightly lower than in previous years; but all the values are very accordant, the extreme difference having been 0·135 foot. This year's value is ·05 foot below the mean value.

The main solar tide is very slightly less in amplitude than in the previous years, and the main lunar tide is a little greater; the epochs of both tides are nearly identical with last year's values.

The proportion which the main solar tide bears to the main lunar tide is rather less than has been found in the three previous years, and is considerably below the theoretical value, being 0·348 against 0·476.

With regard to the two lunar elliptic tides, the smaller (L) is only about half the value obtained last year, and is slightly less in its proportion to the main tide than its theoretical value.

The larger component (N) is slightly less than in former years, but fairly concordant; it is rather greater in proportion to the main tide than theory allows.

The smaller evectional semi-diurnal tide (λ) has a value which is nearly the mean of those obtained at this port. This tide is about half as large again here as theory gives it, agreeing exactly with Beypore, whilst at Bombay the mean value of the proportion is exactly the theoretical one.

The larger evectional tide (ν) is much smaller this year than has been before found, being only about half the value of the previous year; its proportion to the main tide approaches very nearly to the theoretical one, being ·033 against ·037.

The variational tide (μ) is rather larger than last year, but its proportion is not much greater than theory gives, being ·029 against ·022.

This being the fourth year of the observations, a second value of the solar elliptical tides (R and T) has been obtained (two years' observations being necessary for each value).

The smaller component (R) is slightly larger than before; the mean of the two gives exactly the theoretical proportion.

The larger component (T) is considerably greater than its former value, and its proportion to the main tide is 50 per cent greater than theory gives, whilst the last value at this port exactly agreed with the theoretical value.

The semi-diurnal component of the luni-solar declinational tide (R_2 of K) has nearly the same proportional value as last year, which is somewhat less than the theoretical value.

With regard to the diurnal tides, they all agree well with the values obtained in the previous years; they are on the whole a little smaller in proportion to the main tide with the exception of the diurnal lunar tide, which is about double its former value.

The proportions of P to O and J to Q both exceed the theoretical limit, while that of O to K is less than it.

The over-tides of S and M agree very well with the values of previous years, and call for no special mention.

With regard to the long-period tides, the lunar tides have all much the same proportional values as before found.

The solar annual tide is rather less than was found last year, but is about the mean of the values of the four years.

The semi-annual has a proportional value, the same as in 1877-78, but less than the two previous years. Its epoch is more than half a month later than last year.

The time of maximum of the solar annual is exactly the same as last year, viz. 23rd January.

VALUES OF THE TIDAL CONSTANTS, BEYPORE, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Beypore :—

Short-Period Tides.

	S	M	O	K	P	J	Q	L	N	λ	ν	μ	R	T	MS	2SM
A_0	5·412	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·093	0·056	0·329	0·678	0·197	0·063	0·081	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	197·29	142·03	339·81	135·27	327·29	161·23	340·10	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·303	0·901	.....	0·085	.....	.....	.....	0·021	0·191	0·013	0·051	0·006	...	...	...	0·004
ϵ_2	21·78	339·87	.....	355·34	.....	.....	.....	146·21	300·38	106·55	351·98	199·09	...	...	...	243·56
R_3	.....	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	196·47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·004	0·018	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·005	...
ϵ_4	132·80	49·14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	98·30	...
R_6	0·003	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	265·76	178·10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·001	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ^8	45·00	131·32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	... ...	$R = 0·108$	$\epsilon = 349°·81$
„ fortnightly „	... ...	$R = 0·021$	$\epsilon = 26°·05$
Luni-solar „ „	... ...	$R = 0·017$	$\epsilon = 276°·62$
Solar annual „	... ...	$R = 0·328$	$\epsilon = 310°·74$
„ semi-annual „	... ...	$R = 0·180$	$\epsilon = 208°·39$

The mean level of the sea (A_0) from the 1880-81 observations was found to be 5·412 feet above the zero of the gauge, being ·020 higher than that obtained last year and ·027 than that of the year before.

The main lunar tide (R_2 of M) is almost identical in amplitude and epoch with the values of the two preceding years.

The amplitude of the main solar tide (R_2 of S) is almost the same as obtained last year, and its epoch differs but very slightly.

The proportion between the two main tides (R_2 of M and R_2 of S), ·342, is still less than was found in the two preceding years, and is greatly less than the theoretical value, which is ·476. With the exception of the places in the Gulf of Cutch, this is the smallest proportion yet obtained in India; the value at Karwar being the nearest to it.

The smaller lunar elliptic semi-diurnal tide (L) has not quite half the value found last year, but agrees very fairly with the value of 1878-79 and the proportion given by theory.

The proportion of the larger component (N) to the main lunar tide is very nearly the same as was found in the two previous years, and is slightly greater than the theoretical proportion.

With regard to the two evectional tides (λ and ν), λ is nearly the same value as last year, ν is slightly greater, and both considerably exceed the theoretical proportion.

The variational tide (μ) is only about one-third as large as in the previous years, and its proportion to the main lunar tide is much less than what is given by theory.

The luni-solar declinational semi-diurnal tide (R_2 of K) has a value almost identical with that obtained last year; its proportion is considerably less than the theoretical one.

With regard to the diurnal tides, the chief one (R_1 of K) is a little less than the values of the previous years, but is still greater than has been found at any port except Aden.

The proportions of the other diurnal tides to the main lunar tide do not differ much from the value obtained in the previous years, except R_1 of M, which is 6 per cent of the main tide, a proportion which has only been slightly exceeded one year at Aden.

The luni-solar compound semi-diurnal tide (2SM) agrees well with the values of previous years.

The over-tides of S and M present no remarkable features, except the rather larger proportion of the lunar quarter-diurnal to the main tide, a peculiarity noticed in the previous years.

The proportion between the solar and lunar diurnal declinational tides (P and O) is ·599, which is larger than has yet been obtained, and slightly exceeds the maximum limit given by theory.

The proportion between J and Q is much larger than in previous years, and considerably greater than the theoretical proportion.

The proportion between O and K is slightly less than in the two previous years, and is less than the theoretical minimum proportion.

With reference to the long-period sides, the lunar monthly equals 12 per cent of the main tide, which is a larger value than before obtained at any port in India.

The lunar fortnightly is only about one-fifth of the values obtained in the previous years, which, however, were two or three times as great as had been found at other Indian ports.

The luni-solar fortnightly is also much smaller than the previous years'. The values of both these lunar tides, as deduced from this year's observations, agree much better with the general values of the Indian ports than those previously obtained.

The amplitude of the solar annual tide is about a mean between the two previous values, and its epoch agrees very well with previous years, the maximum occurring same day as in 1878-79.

The solar semi-annual is rather less than last year, being 20 per cent of the main tide, instead of 28 per cent: its amplitude is still, however, much greater than at any other port on the west coast. Its epoch is about nine days earlier than in 1878-79 and a fortnight later than in 1879-80.

VALUES OF THE TIDAL CONSTANTS, PAUMBEN, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Paumben:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2 *SM*
A_0	2·759	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·035	0·018	0·116	0·294	0·108	0·014	0·023	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	153·29	190·38	323·69	126·27	315·78	114·95	12·12	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·377	0·601	.....	0·113	.....	.....	.....	0·018	0·084	0·008	0·030	0·012	...	...	...	0·012
ϵ_2	91·35	43·83	.....	70·79	.....	.....	.....	244·60	30·09	171·81	12·85	90·65	...	...	...	341·92
R_3	.....	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	161·62	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·004	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·18	...
ϵ_4	281·87	194·87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	283·83	...
R_6	0·005	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	195·46	33·90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·004	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	257·20	294·83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·034$ $\epsilon = 22°·84$
„ fortnightly „	...	...	$R = 0·052$ $\epsilon = 335°·25$
Luni-solar „	...	...	$R = 0·027$ $\epsilon = 158°·99$
Solar annual „	...	...	$R = 0·164$ $\epsilon = 286°·80$
„ semi-annual „	...	...	$R = 0·184$ $\epsilon = 116°·70$

The mean level of the sea (A_0) was found to be 2·759 above the zero of the gauge, being slightly higher than the values found in the two preceding years, which were 2·666 and 2·707 respectively.

The main lunar tide (R_2 of M) is slightly larger than the values for preceding years; its epoch is the same.

The main solar side (R_2 of S) agrees extremely well both in amplitude and epoch with former values.

Resulting from this we find the proportion between the two main tides is much the same as in previous years, being ·627 as compared with ·652 and ·645 in the two preceding years. This proportion is abnormally high, Tuticorin being the only other Indian port where the theoretical proportion, 0·476, has been exceeded.

The proportion of the smaller lunar elliptic semi-diurnal tide (L) to the main tide is but very slightly in excess of the theoretical value, whilst that of the greater co-efficient (N) considerably less, being about a mean of the proportions found in the previous years.

With regard to the two lunar perturbation tides (λ and ν), λ is only one-third as large as was found last year, and approaches more nearly to the theoretical proportion than has yet been found here, but is still nearly twice as great

The proportion of ν is nearer to that given by theory than last year's value, but is considerably in excess.

The variational semi-diurnal tide (μ) is nearly the same in value as last year, and its proportion to the main tide approaches very nearly to the theoretical value.

The luni-solar declinational semi-diurnal tide (R_2 of K) is nearly exactly the same as was found for the two preceding years, and at this port is higher in its proportion to the main tide than has been found in any Indian ports except Tuticorin.

With regard to the diurnal tides, they agree well with the results of the two previous years. The principal one (R_1 of K) is slightly less than the preceding years; its value is greater than those found at the ports of the east coast and less than those of Aden and the west coast, except Bombay.

R_1 of S is nearly identical in value and proportion to the main tide with the result of 1878-79, which agrees with the Tuticorin values.

The proportions of the other diurnal tides to the main tide agree closely with the results of the previous years.

The proportion of the solar and lunar declinational tides (P and O) is still greater than was found in the last two years, and very much greater than the maximum value assigned by theory, which is 0·572, the proportion found this year being 0·931.

The proportion of J to Q is nearly the same as last year, being greater than theory has assigned, as has generally been found, except at Tuticorin and here in 1878-79.

The proportion of O to K agrees with the former values, and is lower than is generally found.

The overtides call for no special remarks; they agree very closely with former values.

With regard to the long-period tides, the lunar monthly is only about half the amount found in the last two years.

The lunar fortnightly agrees well with the former values, whilst the luni-solar fortnightly is twice as large as the previous values.

The solar annual tide is larger than previously found, being 27 per cent of the main tide (but although it has increased, the solar semi-annual tide continues to exceed it), and is 31 per cent. of the main tide, exactly the same proportion which was found last year.

The epoch of the annual tide does not agree very well with that of last year, being more than a month earlier, occurring early in January, which was nearly the time found in 1878-79.

That of the semi-annual occurs about the middle of May and November, which is about the same date as the two previous years.

VALUES OF THE TIDAL CONSTANTS, MADRAS, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Madras:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*SM*	*2SM*
A_0	2·202	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
k_1	0·026	0·002	0·004	0·257	0·004	0·012	0·003	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_1	90·19	66·34	214·00	19·41	251·08	31·05	70·27	.....	.....	.....	.....	.....	.....	.....	...	.....
R_2	0·445	1·062	.....	0·175	.....	.....	.....	0·017	0·237	0·025	0·007	0·049	0·010	0·056	...	0·022
ϵ_2	274·27	244·65	.....	255·99	.....	.....	.....	158·79	233·12	190·45	285·24	163·19	264·08	333·71	...	221·00
R_3	.....	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_3	.....	52·06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_4	0·002	0·001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·001	.....
ϵ_4	168·00	110·77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	53·21	.....
R_6	0·001	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_6	98·75	142·42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
R_8	0·000	0·001	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
ϵ_8	65·44	76·24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}049$ $\epsilon = 130°{\cdot}38$
„ fortnightly „	...	...	$R = 0{\cdot}047$ $\epsilon = 325°{\cdot}25$
Luni-solar „	„	...	... $R = 0{\cdot}034$ $\epsilon = 47°{\cdot}88$
Solar annual	„	...	... $R = 0{\cdot}335$ $\epsilon = 224°{\cdot}82$
„ semi-annual	„	...	... $R = 0{\cdot}383$ $\epsilon = 148°{\cdot}67$

The mean level of the sea (A_0) is 2·209 feet above the zero of the gauge, being 0·042 foot less than last year's value.

The main lunar tide (R_2 of M) agrees well both in amplitude and epoch with the value obtained last year.

The same remark applies to the main solar tide (R_2 of S).

As may be imagined from the foregoing, the proportion between the two main tides (R_2 of M and R_2 of S) is the same, 0·419, as was obtained last year, being less than the theoretical value.

The smaller lunar elliptic semi-diurnal tide (L) has an amplitude of not much more than one-third of the amount found last year; its proportion to the main tide is considerably less (·046) than the theoretical proportion, which is ·027, and is only about half what has been found at Vizagapatam and Paumben.

With regard to the larger elliptic semi-diurnal tide (N), its proportion to the main tide is slightly less than last year, but is greater than the theoretical proportion, and very much the same as at Vizagapatam.

With reference to the two evectional tides (λ and ν), λ is nearly the same in value and proportion to the main tide as last year, the proportions being much greater than given by theory.

The value of ν is extremely small, and its proportion to the main tide is much below the theoretical value, being less than has yet been found at any Indian port.

The variational tide (μ) is nearly the same as last year, and its proportion to the main tide is about double the theoretical value, whilst at Vizagapatam and Paumben it has been found to be rather less than it.

The solar elliptic semi-diurnal tides (R and T) have been deduced for the first time for Madras (two years' observations being necessary). With regard to the smaller component (R), the proportion to the main tide is nearly four times the theoretical value, and is a mean between the values of Vizagapatam and Paumben; whilst the larger component (T) is nearly twice as large as the theoretical value, and is much larger than at Vizagapatam and rather smaller than at Paumben. Both these tides approximate nearly in value to those found at Beypore.

The luni-solar declinational semi-diurnal tide (R_2 of K) is rather less than in the preceding year, and is in defect of the theoretical value. It is slightly less than at Vizagapatam, and only about half what was found at Paumben.

The luni-solar compound semi-diurnal tide (2SM) agrees nearly exactly with last year's value.

The distinctive feature of the Madras tides, viz. *the very small proportion which the diurnal tides bear to the main lunar tide*, is borne out by the result of this year's observations.

The solar diurnal tide (R_1 of S) is considerably less than last year, and agrees with the mean of the two years at Vizagapatam.

The solar declinational diurnal tide (R_1 of P) is exactly the same as last year.

The luni-solar declinational diurnal tide (R_1 of K) is slightly less than last year, and agrees well with the Vizagapatam value, but is only about half that found at Paumben.

The proportion of the lunar diurnal tide (R_1 of M) to the main tide is so small as to be barely appreciable, and is the smallest yet obtained at any Indian port.

The lunar declinational diurnal tide (R_1 of O) is slightly less than last year.

The elliptic diurnal tide (R_1 of J) is only a little more than one-third the amount that was found last year, and is only half the value at Vizagapatam and Paumben. The other elliptic diurnal tide (R_1 of Q) is the same as last year and insignificant in amount.

The lunar and solar over-tides are very small at Madras.

With regard to the long-period tides, the results of this year's observations confirm the very high value of the solar-annual and semi-annual tides, in proportion to the main tide, which was found last year, shewing that the mean level of the sea at Madras in November was 17 inches higher than in March and April.

The proportion between the solar annual tide and the main tide is slightly smaller this year than in the previous one, 0·315 against 0·356. On the other hand, the proportion of the semi-annual tide is considerably greater than last year, being 0·361 against 0·263. Thus the general effect of these tides in raising the level of the sea is nearly the same as last year.

The epoch of the solar annual tide, which last year was about the 10th October, is this year the 2nd November.

The epochs of the semi-annual tide last year were the 20th May and 20th November. This year they are the 4th June and 4th December.

Thus the maximum combined effect of the solar-annual and semi-annual tides would seem to occur in November, and this is borne out by the tidal diagrams, which give the mean sea-level in November 1·36 feet higher than in March and April.

The lunar monthly tide is slightly larger than last year, and is about a mean between Vizagapatam and Paumben.

The lunar fortnightly tide is a little greater than the last year's value, being very nearly the same as at Vizagapatam and about half the value found at Paumben.

The luni-solar fortnightly tide, which last year was hardly appreciable, is this year considerably larger, and is about the same as the mean of the last three years at Vizagapatam and Paumben.

VALUES OF THE TIDAL CONSTANTS, VIZAGAPATAM, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Vizagapatam :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	4·502	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·035	0·002	0·140	0·369	0·117	0·016	0·004	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	92·47	312·38	253·67	62·79	226·12	30·85	226·73	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·651	1·474	.....	0·158	.....	.....	.....	0·027	0·294	0·012	0·002	0·016	...	...	...	0·015
ϵ_2	286·00	252·38	.....	207·26	.....	.....	.....	160·82	249·20	61·98	79·14	213·49	...	...	...	287·29
R_3	.....	0·006	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	38·35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·003	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·014	...
ϵ_4	59·19	334·52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	17·42	...
R_6	0·001	0·003	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	213·00	23·37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·003	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	60·32	324·38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}051$ $\epsilon = 104°{\cdot}02$
„ fortnightly „	...	...	$R = 0{\cdot}057$ $\epsilon = 337°{\cdot}81$
Luni-solar „ „	...	...	$R = 0{\cdot}038$ $\epsilon = 316°{\cdot}49$
Solar annual „	...	...	$R = 0{\cdot}577$ $\epsilon = 188°{\cdot}65$
„ semi-annual „	...	...	$R = 0{\cdot}458$ $\epsilon = 140°{\cdot}37$

The value of the mean level of the sea (A_0) this year is ·1 of a foot less than last year and ·2 less than that of the year before.

The proportion between the two main tides (R_2 of M and R_2 of S) agrees very well with the results of the two previous years, and is slightly less than the theoretical value, 0·442 against 0·476.

With regard to the two lunar elliptic tides, the proportion of the smaller of the two (L) to the main tide is only half what has been found in the last two years, and falls as much below the theoretical proportion as it exceeded it before.

The larger component (N) has a slightly less proportion than previously obtained, and approaches very near to the proportion given by theory, being 0·199 against 0·192.

The smaller evectional semi-diurnal tide (λ) has nearly exactly the same proportion to the main tide as was found in the preceding years, about double the theoretical proportion ; whilst the larger evectional tide is hardly apparent at all this year, agreeing with Madras in this peculiarity, as this year's value of this tide at these two places is by far the smallest yet found at any Indian port.

The proportion of the variational tide (μ) to the main tide is less than in the previous years, and is exactly half the theoretical value.

The proportion of the luni-solar declinational semi-diurnal tide (R_2 of K) is also smaller than in previous years; a mean of the three values would give a value but slightly less than theory assigns.

The smallness of the diurnal tides at Vizagapatam is again shown in the results of this year's observations. The chief of these (R_1 of K) is one-quarter of the main tide, which is the same as was found in the two preceding years.

The remaining diurnal tides do not differ much from the values of the former years, and with the exception of the solar declination diurnal (P), which is slightly larger, they are all of less amplitude than previously found.

The lunar-diurnal tide especially being almost imperceptible.

The lunar and solar over-tides are small, and call for no special mention; the lunar and solar quarter-diurnal tides are each about one per cent of the main tide.

The proportion between P and O is larger than theory assigns, but agrees well with the value found at Paumben and Madras.

The proportion between J and Q again departs entirely from the theoretical value, which gives Q about 2½ times greater than J. Here J is 3½ times greater than Q. The same or even a larger value is found at Madras and False Point, and Dublat gives nearly the same results.

The proportion between O and K is smaller than the theoretical one, and it agrees with the value at Paumben and Port Blair, and is less than at any other port except Madras.

With regard to the long-period tides, the solar-annual and semi-annual continue to shew the very high proportion to the main tide, which is a distinguishing feature of this port, and is only surpassed in India by the two riverain ports of Kidderpore and Moulmein.

The solar-annual tide indeed is less than in the two former years, but is still 39 per cent of the main tide; last year it was 57 per cent. and the year before 49. Its epoch this year is the end of September, being the same time as was found two years ago.

The solar semi-annual is greater this year than before, reaching the very large proportion of 31 per cent of the main tide, which is larger than has yet been found in any Indian port except at Madras for this same year, when it was 36 per cent. Its epoch is later than before found, occurring on the 1st June and 1st December.

The other long-period tides require no special mention.

VALUES OF THE TIDAL CONSTANTS, FALSE POINT, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at False Point:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	7·552	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·006	0·015	0·168	0·398	0·133	0·020	0·004	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	325·24	173·42	256·32	64·91	250·22	23·11	227·81	.....	.....	.....	.....	.....	...	...	...	...
R_2	1·000	2·274	.....	0·247	.....	.....	.....	0·062	0·477	0·040	0·163	0·072	...	...	...	0·019
ϵ_2	301·55	266·99	.....	279·25	.....	.....	.....	85·70	263·33	94·87	244·83	262·18	...	...	...	197·99
R_3	.....	0·012	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	30·05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·007	0·030	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·039	...
ϵ_4	331·19	220·16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	270·38	...
R_6	0·003	0·009	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	153·44	74·06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·003	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	218·93	221·15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly	tide	...	...	$R = 0·055$ $\epsilon = 53°·15$
„ fortnightly	„	...	...	$R = 0·055$ $\epsilon = 13°·62$
Luni-solar	„	...	...	$R = 0·042$ $\epsilon = 280°·81$
Solar annual	„	...	...	$R = 0·746$ $\epsilon = 166°·12$
„ semi-annual	„	...	...	$R = 0·364$ $\epsilon = 142°·23$

The mean level of the sea is found to be 7·552 feet above the zero of the gauge, or 12·99 feet below bench-mark A.

The main tides of S and M have amplitudes of 1·01 and 2·27 feet respectively, exemplifying the increasing amplitudes of the tides of the ports on the east coast, going north from Paumben.

The proportion between the two main tides is 0·442, which is a little less than the theoretical proportion of 0·476. This proportion is nearly exactly the same as is found at Vizagapatam, and slightly greater than at Madras.

With regard to the two lunar elliptic tides, the proportion of the smaller of the two (L) to the main tide is exactly what is given by theory ·027, and agrees well with the mean values at Vizagapatam and Madras.

The larger component (N) also agrees very fairly with the theoretical value, being ·210 against ·192. The Vizagapatam mean value is almost identical, and the Madras value slightly larger.

The smaller evectional semi-diurnal tide (λ) has a value about three times the theoretical one, and about a mean between the Madras and Vizagapatam values. The theoretical value of this tide has been exceeded in all the Indian ports, except the three on the west coast.

The larger evectional tide (ν) is twice the theoretical proportion, in this instance differing from the two other east coast ports, where the mean value of this tide has nearly agreed with theory.

The variational tide (μ) is about half as large again as it should be theoretically; its value being about a mean between the mean values at Madras and Vizagapatam.

The proportion of the luni-solar declinational semi-diurnal tide (R_2 of K) to the main tide is rather less than theory assigns; the value found here agrees well with the means of Madras and Vizagapatam.

One of the distinguishing features of the tides at this port, as at the other two east coast ports, is the very small proportion which the diurnal tides bear to the main lunar tide. This is more marked here than at either Madras or Vizagapatam, which may be shown by the fact that at Madras the sum of all the diurnal tides would equal 52 per cent of the main lunar tide; at Vizagapatam 49 per cent, and at False Point only 33 per cent.

The chief diurnal tide (R_1 of K) is hardly 18 per cent of the main tide. The lunar and solar diurnal tides are insignificant; as are also the two lunar elliptic diurnal tides J and Q; whilst the solar and lunar declinational diurnal tides, P and O, are only 6 and 7 per cent respectively of the main tide.

The over-tides of S and M are all insignificant in amount, and call for no special mention.

With regard to the long-period tides. The solar annual, although not so large as at Vizagapatam, amounts to 33 per cent of the main tide, which is almost the same proportion as was found at Madras.

The solar semi-annual is about half the proportional amount which was found at Madras, and two-thirds of the value at Vizagapatam.

The time of maximum of the solar-annual tide at False Point is the 4th September, and the maxima of the semi-annual tide occur on the 1st June and December.

At Vizagapatam the maximum of the solar annual tide seems to occur during the latter portion of September, and at Madras in October.

The times of maxima of the semi-annual tide seems to be nearly the same for all the three east coast ports and for Port Blair.

The lunar long period tides are smaller in proportion to the main tide than have been found either at Madras or Vizagapatam, but they call for no special comment.

VALUES OF THE TIDAL CONSTANTS, KIDDERPORE, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Kidderpore:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	10·739	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_1	0·004	0·020	0·220	0·352	0·146	0·016	0·058	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_1	196·96	221·98	302·09	133·73	311·93	72·94	278·51	.....	.....	.....	.....	.....	.....	.....	...	...
R_2	1·422	3·633	.....	0·409	.....	.....	.....	0·190	0·685	0·127	0·337	0·229	.....	.....	...	0·065
ϵ_2	101·81	56·49	.....	72·91	.....	.....	.....	250·70	45·88	308·95	335·89	169·99	.....	.....	...	336·10
R_3	.....	0·012	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_3	.....	331·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_4	0·002	0·750	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·633	...
ϵ_4	126·45	34·82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	79·97	...
R_5	0·002	0·163	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_5	200·37	346·45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
R_6	0·002	0·077	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...
ϵ_6	297·16	257·63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...

Long-Period Tides.

Lunar monthly tide	...	... $R = 0{\cdot}328$	$\epsilon = 0°{\cdot}38$
„ fortnightly „	...	... $R = 0{\cdot}278$	$\epsilon = 17°{\cdot}18$
Luni-solar „ „	...	... $R = 0{\cdot}338$	$\epsilon = 36°{\cdot}56$
Solar-annual „	...	... $R = 2{\cdot}809$	$\epsilon = 157°{\cdot}08$
„ semi-annual „	...	... $R = 0{\cdot}935$	$\epsilon = 204°{\cdot}56$

The mean level of the river from this year's observations is 10·739 feet above the sill of the Kidderpore Dock. The mean value of the five former years being 10·489 feet, the present value is therefore 3 inches higher.

The tides at Kidderpore, owing to its situation high up a large river, are not comparable with those of any of the Indian ports, except Rangoon and Moulmein, whose situation is similar; and it is with the results of the observations at these ports that the comparisons are chiefly made.

The amplitudes of the main tides of S and M are slightly greater than the mean of the previous values. Their epochs are nearly identical with the value in 1877-78, but differ by 22 minutes from the mean value of the five years which had been previously used.

The proportion between the main tides is less than the mean value obtained before, and considerably less than the theoretical value, being 0·393 against 0·476; it is rather more than the value obtained at Rangoon and Moulmein, which is 0·360.

The main lunar elliptic semi-diurnal tide (R_2 of N) has a proportion to the main tide nearly exactly the same as given by theory, 0·189 against 0·192. This is identically the same proportion as was found to obtain both at Moulmein and Rangoon.

The smaller component (L) has a proportion of about twice that given by theory, but approaching it more nearly than at Moulmein and Rangoon.

The larger evectional semi-diurnal tide (ν) is 9 per cent of the main tide, the theoretical value being a little less than 4 per cent. This is the same value as found at Rangoon, but a little larger than at Moulmein.

The smaller evectional semi-diurnal tide (λ) is five times as great as the theoretical proportion; the value of this tide is very large in proportion at Dublat also, and all the stations in Burma.

The proportion of the variational semi-diurnal tide (μ) to the main tide is slightly less than before obtained, and is about three times greater than the theoretical proportion; at Moulmein and Rangoon it is found to be four times as great.

The proportion of the luni-solar declinational tide (R_2 of K) to the main tide is very nearly the theoretical one, being 0·113 against 0·127; it is higher here than at Moulmein and Rangoon.

The proportion of the luni-solar compound semi-diurnal tide to the main tide is ·023, which is nearly the same as was found at Dublat, but is one-third less than at Moulmein and Rangoon.

The proportions of the diurnal tides to the main tide are smaller than were previously found: the chief diurnal tide (R_1 of K) being only 10 per cent of the main tide, in this it agrees with the other two riverain ports, where it is 12 per cent.

All the diurnal tides in the Bay of Bengal have smaller proportions to the main tide than prevail in the Indian Ocean, and their proportion seems to be exceptionally small in the riverain ports.

With reference to the over-tides of S, the quarter-diurnal tide R_4 of S is 5 per cent of the main tide, which is the same as at Moulmein and Rangoon; the other over-tides are insignificant.

The lunar over-tides are larger in proportion than the solar, the lunar quarter diurnal being 21 per cent of the main tide—an amount which has only been equalled at Moulmein, where it is 24 per cent, whilst at Rangoon it is only 7 per cent.

The lunar sexter-diurnal over-tide (R_6 of M) is also very great in proportion, being 4½ per cent of the main tide, which is the largest proportion yet obtained in India, but which is very nearly equalled at Rangoon. The remaining over-tide R_4 of M is 2 per cent of the main tide, being the largest value yet obtained in India.

The compound luni-solar quarter diurnal tide (MS) is 13 per cent of the sum of the amplitudes of the two main tides (R_2 of S and R_2 of M) with the exception of Moulmein, where it is 14 per cent. This also is the largest value yet obtained in India.

With regard to the long-period tides, their very large proportion, compared with the main tide, is again apparent.

The chief tide of the solar annual is 77 per cent of the main tide, which is the largest value ever yet found. At Moulmein, where the next largest value was found, it was 64 per cent, and at Rangoon 29 per cent. The epoch of this tide is very nearly the mean epoch of the former years, shewing it to occur on the 28th August, and indicating that its cause may be ascribed to rainfall.

The solar semi-annual tide is 26 per cent of the main tide, which is considerably more than was found either at Moulmein or Rangoon. The epoch of this tide differs greatly from the mean, or any of the values of former years; from this year's observations its maximum should occur at the beginning of July and January, whilst the former dates were the beginning of September and March.

The next in importance is the luni-solar fortnightly tide, which is 23 per cent of the main tide, which is remarkably high, though exceeded at Moulmein, where it is 29 per cent. At Rangoon it is 9 per cent.

The lunar fortnightly tide is 8 per cent of the main tide, and the lunar monthly 9 per cent, both these proportions being considerably in excess of what has been found at any Indian port except Moulmein, Paumben, and Beypore.

VALUATION OF THE TIDAL CONSTANTS, DIAMOND HARBOUR, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Diamond Harbour :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*2L*	*T*	*MS*	*2SM*
A_0	9·263	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·062	0·033	0·229	0·488	0·176	0·028	0·023	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	156·14	196·61	265·03	26·21	276·13	16·27	289·81	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·215	5·238	.....	0·619	.....	.....	.....	0·163	1·000	0·173	0·425	0·278	...	...	...	0·026
ϵ_2	26·06	342·78	.....	2·26	.....	.....	.....	161·42	357·15	196·70	291·82	75·12	...	...	...	253·37
R_3	.....	0·043	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	216·20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·117	0·774	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·036	...
ϵ_4	328·55	242·36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	233·55	...
R_6	0·018	0·161	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	266·42	190·26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·008	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	304·70	332·13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R =$	$\epsilon =$
„ fortnightly „	...	...	$R =$	$\epsilon =$
Luni-solar „	„	...	...	$R =$	$\epsilon =$
Solar annual	„	...	...	$R =$	$\epsilon =$
„ semi-annual	„	...	...	$R =$	$\epsilon =$

Not computed.

The mean level of the river at Diamond Harbour (A_0) is 9·263 feet above the level of the zero of the gauge, which is the level of the Kidderpore Dock sill. The river-level at Kidderpore is 10·74 feet above the sill of the dock, whilst the sea-level at Dublat is approximately 8·55 above the same point.

The amplitudes of the main solar and lunar tides are greater than at Kidderpore or Dublat. The epoch of the main lunar tide differs from the mean of the previous years by about 10 minutes. The crest of this tide will reach Diamond Harbour about 1 hour 50 minutes after Dublat and 2 hours and 26 minutes before Kidderpore.

The proportion of the main solar to the main lunar tide is 0·423, which is rather less than the mean of the previous years, and somewhat in defect of the theoretical value, but is the largest found as yet at any riverain port.

The proportion of the smaller lunar elliptic semi-diurnal tide (R_2 of L) to the main tide is but slightly in excess of the theoretical value, being ·031 against ·027. This is nearly the same proportion as was found at Dublat, and considerably less than at Kidderpore.

The larger component (R_2 of N) may be said to be theoretically correct in its proportion to the main tide, which is the same result as was found at Kidderpore.

The smaller evectional tide (λ) is about five times as great as the proportional value given by theory. This is the same as at Kidderpore.

The larger component (ν) is about twice as great as theory gives, which also agrees closely with the Kidderpore value.

The proportion, of the variational semi-diurnal tide to the main tide is about twice the theoretical value. It is slightly less than at Kidderpore and little larger than at Dublat.

The proportion of the luni solar declinational tide to the main lunar tide is very nearly what is given by theory, being 0·118 against 0·127. Kidderpore and Dublat both give 0·113.

The luni-solar compound semi-diurnal tide (2 SM) is 2 per cent of the main tide, which is the same as found at Kidderpore and Dublat.

All the diurnal tides at Diamond Harbour are very small, agreeing in this with what was found at Kidderpore and Dublat. The total value of all the diurnal tides at Kidderpore is only 25 per cent of the main tide, whilst at Diamond Harbour and Dublat it is only 20 per cent, the smallest value yet found in India.

The chief diurnal tide (R_1 of K) is only 9 per cent of the main tide, which is a very small value, whilst the solar-diurnal tide is not 2 per cent and the lunar-diurnal less than 1 per cent.

The solar quarter-diurnal tide (R_4 of S) is 5 per cent of its main tide, which is the proportion which has been found at Kidderpore, and also at the other riverain ports. The other over-tides of S are insignificant.

The lunar quarter-diurnal tide (R_4 of M) is 15 per cent of the main tide, which is less than was found at Kidderpore or Moulmein, but is twice as great as at Rangoon.

The sexter-diurnal (R_6 of S) is 3 per cent of the main tide, agreeing in this with the other riverain ports.

The proportion of the amplitude of the compound luni-solar quarter-diurnal tide (MS), as compared with the sums of the amplitudes of the two main tides (R_4 of S and R_4 of M), is 0·093, which is slightly less than found at Kidderpore.

The long-period tides have not been evaluated, pending a correction in the formula for their reduction.

VALUES OF THE TIDAL CONSTANTS, DUBLAT, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Dublat :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	14·394	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·044	0·013	0·174	0·486	0·158	0·030	0·010	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	99·12	92·19	253·00	74·60	245·30	68·69	226·42	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·033	4·679	.....	0·529	.....	.....	.....	0·161	1·054	0·302	0·274	0·223	...	...	...	0·093
ϵ_2	326·81	288·08	.....	293·95	.....	.....	.....	95·23	252·84	156·98	238·92	6·07	...	...	...	196·74
R_3	.....	0·030	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	128·10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·025	0·103	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·093	...
ϵ_4	202·41	138·49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	169·23	...
R_6	0·002	0·013	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	120·47	268·93	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·004	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	115·94	307·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide ...	...	R = 0·047	ϵ = 29°·34
„ fortnightly „ ...	...	R = 0·051	ϵ = 37°·12
Luni-solar „ „ ...	...	R = 0·050	ϵ = 279°·70
Solar annual „ ...	...	R = 0·796	ϵ = 146°·03
„ semi-annual „ ...	...	R = 0·234	ϵ = 162°·17

The mean level of the sea at Dublat was found to be 14·394 feet above the zero of the gauge, and therefore 8·58 feet below bench-mark A.

The position of Dublat is on the sea near the mouth of a large river, and this situation it shares with three other tidal stations in the Bay of Bengal, viz. False Point, Elephant Point, and Amherst, and, allowing for differences of geographical position, we should expect to find the same peculiarities in the tides of all four.

The proportion of the main solar to the main lunar tide is rather less than the theoretical one, being 0·439 against 0·476. The mean proportional value of the four estuary ports is 0·434.

The smaller lunar elliptic semi-diurnal tide (L) at Dublat exceeds the theoretical proportion, as also does the larger component (N). In this also the other estuary ports shew similar values.

With regard to the evectional semi-diurnal tides, the smaller (λ) is very nearly ten times greater than the theoretical value. It is nearly the same value as found at Amherst, and these with Elephant Point give the highest proportions for this tide yet found in India.

The larger component (ν) has also a value about 50 per cent greater than theory gives, but the other estuary ports have a still higher value than this.

The variational semi-diurnal tide (μ) has more than double its theoretical proportional value.

The proportion of the luni-solar declinational semi-diurnal tide (R_2 of K) to the main tide is very slightly less than the theoretical value. In this it agrees well with False Point. One of the chief features of the Dublat tides is the exceedingly small proportion which the diurnal tides bear to the main lunar tide. This is a general feature in all the stations in the Bay of Bengal; but it is most marked at Dublat, where the sum of all the diurnal tides only equals 19½ per cent of the main tide. The lowest value before obtained was 25 per cent at Kidderpore and Rangoon, whilst at the two other estuary stations it is 28 per cent.

The chief diurnal tide (R_1 of K) is only 10 per cent of the main tide. The lunar and solar diurnal tides are insignificant, as also the two lunar elliptic diurnal tides, J and Q, whilst the solar and lunar declinational diurnal tides (P and O) are only 3 and 4 per cent respectively of the main tide.

The over-tides of S and M call for no special remark. They are all very small; the largest, the quarter-diurnal lunar tide, being only 2 per cent of the main tide.

All the long-period tides are small at Dublat. They are nearly the same in total proportional amount as was found at Elephant Point.

The three lunar tides are each only 1 per cent of the main tide.

The solar annual tide is 17 per cent, and the semi-annual 5 per cent.

The time of the maximum of the solar annual tide was the 18th August. This tide seems to occur earlier as one goes up the Bay. At Madras it is in October, at Vizagapatam late in September, at False Point early in September, and here in the middle of August.

The times of maxima of the solar semi-annual are the 12th June and December, very nearly the same time as at False Point.

VALUES OF THE TIDAL CONSTANTS, RANGOON, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Rangoon:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	14·360	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·123	0·009	0·285	0·099	0·148	0·023	0·023	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	128·72	347·11	308·31	115·89	321·68	168·50	309·69	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·003	5·576	.....	0·359	.....	.....	.....	0·316	0·359	0·293	0·291	0·519	0·117	0·290	...	0·157
ϵ_2	170·37	129·84	.....	155·60	.....	.....	.....	322·32	117·51	1·77	73·89	290·64	167·26	207·36	....	56·33
R_3	.....	0·016	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	151·49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·089	0·433	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·419	...
ϵ_4	256·12	167·17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	210·13	...
R_6	0·000	0·234	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	39·29	82·51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·003	0·067	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	117·47	94·95	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	$R = 0·238$	$\epsilon =$	8°·83
„ fortnightly „	$R = 0·208$	$\epsilon =$	2°·91
Luni-solar „	$R = 0·565$	$\epsilon =$	54°·21
Solar annual „	$R = 1·415$	$\epsilon =$	153°·23
„ semi-annual „	$R = 0·012$	$\epsilon =$	314°·51

The value of mean sea-level (A_0) this year is ·094 foot lower than by last year's determination.

The main solar and lunar tides agree almost exactly in amplitudes and epochs with last year's results. The proportion between them is therefore nearly the same as last year, being 0·359 against 0·363, both values being considerably in defect of the theoretical proportion, 0·476, as has been found at all the river stations.

The smaller lunar elliptic semi-diurnal tide (L) is condiderably less than last year, but is still more than double its theoretical proportional value.

The larger component (N) is slightly smaller than last year; but approaches very nearly to the proportional value given by theory, with which it last year was almost identical.

With regard to the evectional tides, the smaller (λ) is identical with last year's value, and is about eight times larger than the theoretical value, which is the same result as was found at Moulmein.

The larger component (ν) is about one-third less than last year, but is still 50 per cent greater than the theoretical proportional value.

The variational tide (μ) is the same in value as last year, which is four times the proportional value given by theory.

The solar elliptic semi-diurnal tides (R and T) have been deduced for the first time this year (two years' observations being necessary).

The smaller component (R) is about five times greater than its proper proportional value; in this it agrees well with the results obtained for this tide at Moulmein.

The larger component (T) has also the same proportional value as was obtained at Moulmein, which is nearly twice as great as theory gives.

The luni-solar declinational semi-diurnal tide (R_2 of K) is nearly identical with last year's value, as also is the luni-solar compound semi-diurnal (2SM).

The diurnal tides at Rangoon are again very small, and agree almost exactly in proportional value with last year's results. Both here and at Moulmein their total amount is only 25 per cent of the main tide, which is also the case at Kidderpore, shewing that the diurnal inequality does not greatly affect tides in rivers.

The lunar and solar over-tides are very accordant with what was found last year.

The solar quarter-diurnal is 4 per cent of the main tide, and the lunar quarter-diurnal is 8 per cent; the sexter-diurnal lunar over-tide (R_6 of M) is also 4 per cent of the main tide. The large values of these over-tides is due to the position of the place, separated from the sea by a considerable length of shallow water, and the same phenomenon is found in the Hughli and Moulmein rivers.

With regard to the long-period tides, the lunar tides have much the same proportion to the main lunar tide as was found last year. These, as well as the solar long-period tides, are considerably less in proportion than at Moulmein and Kidderpore.

The solar annual tide is 25 per cent of the main tide; last year it was 29 per cent, whilst the semi-annual tide is very small.

The epoch of the annual tide is about nine days later than last year, occurring on the 24th August.

VALUES OF THE TIDAL CONSTANTS, ELEPHANT POINT, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Elephant Point:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	16·554	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·113	0·022	0·356	0·817	0·190	0·213	0·045	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	79·37	233·05	277·14	99·13	302·52	137·78	256·34	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·357	5·676	.....	0·405	.....	.....	.....	0·413	1·545	0·660	0·638	0·357	...	...	....	0·042
ϵ_2	143·13	169·29	.....	73·24	.....	.....	.....	278·75	77·89	325·14	206·42	276·14	...	...	...	86·37
R_3	.....	0·025	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	142·86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·057	0·079	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·135	...
ϵ_4	162·30	41·90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	61·45	...
R_6	0·021	0·208	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	93·61	342·71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·003	0·031	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	69·67	313·85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}145$ $\epsilon = 5°{\cdot}85$
„ fortnightly „	...	...	$R = 0{\cdot}102$ $\epsilon = 286°{\cdot}61$
Luni-solar „	...	...	$R = 0{\cdot}059$ $\epsilon = 275°{\cdot}34$
Solar annual „	...	...	$R = 0{\cdot}930$ $\epsilon = 145°{\cdot}63$
„ semi-annual „	...	...	$R = 0{\cdot}261$ $\epsilon = 198°{\cdot}43$

The gauge at Elephant Point being situated nearly on the sea at the mouth of a large river, the tides here are comparable first with Amherst, similary situated on the opposite side of the Bay about 100 miles distant, where we should expect the same phenomena to prevail, and with Dublat and False Point, also situated at the mouths of large rivers.

The mean sea-level was found to be 16·55 feet above the zero of the gauge.

The amplitudes of the two main tides (R_2 of S and R_2 of M) are 2·3 feet and 5·9 feet respectively, the corresponding values at Amherst being 2·9 and 6·2. The proportion of the main solar to the main lunar tide is 0·398, which is less than that found at any of the other estuary ports, and considerably less than the theoretical value, 0·476.

The proportion between the smaller of the lunar elliptic semi-diurnal tides (L) and the main tide is about 2½ times that given by theory, whilst at the other estuary ports the agreement is close.

With regard to the larger component (N), it is rather greater than the theoretical proportion, being 0·263 against 0·192.

The two lunar perturbational tides (λ and ν) are very much larger than assigned by theory, and are the largest proportions yet found in India.

The variational semi-diurnal tide (μ) is about three times as great as theory allows, and is nearly the same proportion as is found at Amherst.

The luni-solar compound semi-diurnal tide (R_2 of K) has a value of only about half the theoretical one. In India this tide has generally been found to agree very well with theory.

The luni-solar compound semi-diurnal tide (2SM) is very small at Elephant Point, only about one-fourth the value found at Amherst and one-third the value at Dublat. A distinctive feature of the Elephant Point tides is the small value of the diurnal tides; in this it agrees with Amherst, Rangoon, and all the stations in Burma and the Bay of Bengal generally. The most important of the diurnal tides, the luni-solar declinational diurnal tide, is only 14 per cent of the main tide, whilst on the west coast of India it ranges from 40 to 80 per cent.

The solar diurnal is only about one-half the proportional value to the main tide that is generally found in India. R_1 of O, the lunar declinational diurnal tide, is less than one-third of the general proportional value, whilst the other diurnal tides are insignificant in their proportion to the main tide.

There is nothing to call for special remark in the over-tides either of S or M, except the rather large value of the sexter-diurnal lunar tide.

With regard to the long-period tides, they have small proportional values as compared with the other Burman ports, but agree very well with the values found at Dublat.

The lunar long-period tides are all considerably less in value than the general mean of Indian values.

The solar annual tide is 16 per cent of the main tide; at Dublat it is 17 per cent, and at Amherst 10 per cent.

Its time of maximum occurs at the middle of August, which is the same time as has been found at Rangoon.

VALUES OF THE TIDAL CONSTANTS, MOULMEIN, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Moulmein: —

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	8·659	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·020	0·032	0·242	0·457	0·144	0·018	0·032	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	154·60	209·27	330·08	121·65	331·19	124·60	335·71	.....	.....	.....	.....	.....	...	...	...	...
R_2	1·344	5·743	.....	0·261	.....	.....	.....	0·260	0·650	0·252	0·218	0·522	0·097	0·200	...	0·139
ϵ_2	145·31	110·34	.....	133·25	.....	.....	.....	319·87	104·39	0·18	89·33	254·50	176·10	189·37	...	42·27
R_3	.....	0·032	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	211·81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·009	0·302	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·719	...
ϵ_4	225·18	165·63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	206·09	...
R_6	0·006	0·111	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	187·13	191·09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·001	0·033	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	251·57	132·52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	... ...	$R = 0{\cdot}459$	$\epsilon = 17°{\cdot}43$
„ fortnightly „	... ...	$R = 0{\cdot}346$	$\epsilon = 16°{\cdot}25$
Luni-solar „ „	... ...	$R = 1{\cdot}110$	$\epsilon = 49°{\cdot}86$
Solar annual „	... ...	$R = 2{\cdot}389$	$\epsilon = 152°{\cdot}84$
„ semi-annual „	... ...	$R = 0{\cdot}653$	$\epsilon = 283°{\cdot}89$

The value of the mean sea-level (A_0) above the zero of the gauge is found to be 0·2 foot greater from this year's observations than from the last.

The amplitudes of both the main tides are slightly less this year than last. The proportion between them, 0·359, is almost identically the same as last year, and is much less than the theoretical value, 0·476. It is nearly the same proportion as is found at Rangoon.

The lesser lunar elliptic semi-diurnal tide (L) is nearly half as large again as last year, and its proportion to the main tide is nearly four times greater than assigned by theory, being rather larger than the proportion found at Rangoon, and nearly twice as great as that at Kidderpore.

The larger component (N) has nearly the same proportion as last year, and is but slightly in defect of the theoretical value, being 0·182 against 0·192; Kidderpore and Rangoon both being 0·189.

With regard to the lunar perturbational tides, the evectional tide (λ) is one-third higher in its proportion to the main tide than was found last year, being ·067 against ·041. This is very much higher than the theoretical proportion, which is only ·007, but agrees well with the values found at Dublat, Amherst, and Rangoon.

The proportion of the larger component (ν) is ·058, theory giving ·037.

The proportion of the variational tide (μ) is about four times the theoretical one, being ·086 against ·022. Rangoon gives ·090 and Kidderpore ·063.

The solar elliptic semi-diurnal tides (R and T) have been deduced for the first time this year (two years' observations being necessary). With regard to the smaller component (R), its proportion to the main tide is 6¼ times the theoretical value, and is the highest value yet obtained for this tide except one year at Kurrachee, and lately at Amherst. The larger component (T) has a proportion about twice that given by theory—a result which differs little from what has been found at several of the other ports.

The luni-solar declinational semi-diurnal tide (R_2 of K) is less this year, being only 7 per cent of the main tide, or about half the theoretical proportion. The luni-solar compound semi-diurnal tide is very much the same as was found last year, and agrees well with what was found at Rangoon.

The diurnal tides are nearly identical this year with the values of the previous one, and their values are very small, as was also found at the riverain ports of Rangoon and Kidderpore.

The quarter-diurnal tides, both solar and lunar, are nearly exactly the same in amount as was found last year; the solar over-tide being 5 per cent and the lunar 24 per cent of the main tide. This very large proportion is a marked characteristic of the Moulmein tides, which has been found at no other place except at Kidderpore, where the two combined are equal to 25 per cent of the main tide.

With regard to the long-period tides at Moulmein, the solar annual tide is by far the largest, being 64 per cent of the main tide. The same value was found last year. This is the largest proportion found anywhere save at Kidderpore. Its epoch agrees very well with last year, and is about the middle of August, shewing that it has to do with the rainfall.

The solar semi-annual tide this year is 17 per cent of the main tide Its times of maximum agree exactly with those of last year—the middle of August and the middle of February.

The solar monthly tide is rather larger than last year, and is 12 per cent of the main tide, the highest value yet obtained at any Indian port.

The lunar fortnightly tide is slightly larger than last year, amounting to 9 per cent of the main tide, which is a very high value.

The luni-solar fortnightly tide is also slightly larger than last year, and is actually 30 per cent of the main tide—an abnormally high value—which is only approached by Kidderpore, where this tide was 23 per cent of the main tide.

VALUES OF THE TIDAL CONSTANTS, AMHERST, 1880-81.

The following are the amplitudes and epochs deduced from the 1880-81 observations at Amherst :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2*SM*
A_0	13·591	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·428	0·032	0·312	0·671	0·132	0·111	0·064	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	178·00	325·05	248·33	84·59	217·74	90·22	245·41	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·851	6·219	.....	1·753	.....	.....	.....	0·239	1·378	0·393	0·427	0·446	...	...	...	0·18
ϵ_2	266·69	67·81	.....	73·55	.....	.....	.....	279·55	87·48	290·70	183·39	273·79	...	...	...	347·22
R_3	.....	0·034	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	283·81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·005	0·275	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·280	...
ϵ_4	146·81	56·06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	87·85	...
R_5	0·012	0·071	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_5	221·61	230·81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_6	0·000	0·005	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	209·25	213·74	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Nil.

The value of the mean level of the sea (A_0) above the zero of the gauge is found to be 13·59 feet.

The amplitude of the main solar tide (R_2 of S) is 2·85 feet, which is about twice the amount at Moulmein, and is larger than has been found at either Rangoon or Elephant Point.

The amplitude of the main lunar tide is 6·25 feet, which is also the highest yet obtained at any Burman port.

The proportion between the two main tides is 0·456, which is larger than has been found before in Burma, and approaches nearly to the theoretical value.

Of the two lunar elliptic semi-diurnal tides, the smaller (L) has a proportion to the main tide about 50 per cent larger than assigned by theory, but only about half the value found at Elephant Point, Moulmein, or Rangoon.

The larger (N) is not very much greater in proportion to the main tide than the theoretical value, being 0·221 against 0·192; it is slightly less than at Elephant Point.

With regard to the evectional semi-diurnal tides, the smaller (λ) is nine times greater than theory gives, but agrees with the Moulmein value.

The larger (ν) is not quite double the theoretical value, and also agrees with the mean value at Moulmein.

The variational tide (μ) is more than thrice as great as it should be according to theory.

The luni-solar declinational semi-diurnal tide (R_2 of K) is very large, being 28 per cent of the main tide, which is by far the largest value yet found at any Indian port.

The luni-solar compound semi-diurnal agrees well in value with the value found at Moulmein.

As has been found at all the Burman stations, the diurnal tides are very small at Amherst, their total amount being only 28 per cent of the main tide, which is exactly the value found at Elephant Point, and slightly greater than at Moulmein and Rangoon, where they amounted to 25 per cent.

The main diurnal tide (R_1 of K) is 11 per cent of the main tide, which is the same proportion as found at all the Burman ports

The solar diurnal tide has a large value, being 7 per cent of the main tide—a proportion only equalled at Beypore and Paumben.

The lunar diurnal tide is quite insignificant.

The proportion of P to O falls within the theoretical limits, that of J and Q greatly exceeds, and that of O to K is less than them.

The quarter-diurnal tides of S and M are respectively 3 per cent and 4 per cent of the main tide; the other over-tides call for no special comment.

The long-period tides have not been computed.

The results in this table have been deduced from the observations of eight lunations only, and have not therefore the same value as the results of a full year.

VALUES OF THE TIDAL CONSTANTS, AMHERST, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Amherst :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	13·974	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·145	0·037	0·301	0·082	0·193	0·079	0·057	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	148·53	13·77	259·16	87·74	255·07	83·82	241·64	.....	.....	.....	.....	.....	...	...	...	...
R_2	2·705	6·178	.....	0·771	.....	.....	.....	0·255	1·267	0·234	0·237	0·735	0·431	0·811	...	0·152
ϵ_2	101·22	65·66	.....	64·69	.....	.....	.....	287·37	49·16	213·33	263·24	295·00	353·37	222·99	...	30·50
R_3	.....	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	221·33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·118	0·437	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·412	...
ϵ_4	102·23	47·16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	27·99	...
R_6	0·004	0·153	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	221·06	242·44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·006	0·016	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	318·16	236·03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly	tide	...	...	$R = 0·160$ $\epsilon = 43°·45$
„ fortnightly	„	...	...	$R = 0·054$ $\epsilon = 291°·89$
Luni-solar „	„	...	...	$R = 0·081$ $\epsilon = 78°·37$
Solar annual	„	...	...	$R = 0·638$ $\epsilon = 149°·83$
„ semi-annual	„	...	...	$R = 0·188$ $\epsilon = 138°·72$

The value of the mean level of the sea (A_0) above the level of the zero of the gauge is 13·974 feet; the incomplete year of 1880-81 gave it 13·591.

The main solar and lunar tides agree well, both in amplitude and epoch, with last year's values; the amplitudes in both cases being slightly in defect.

The proportion between the two main tides is less than in the previous year, being 0·438 against 0·456; theory giving 0·476. This value is almost identical with that found at Dublat and False Point, and is rather greater than at Elephant Point.

The lesser lunar elliptic semi-diurnal tide (L) is identical in proportional value with the result obtained last year, about 50 per cent higher than the theoretical value.

The larger component (N) is a little smaller than last year, and approaches very nearly to the theoretical value, being 0·205 against 0·192.

Of the evectional semi-diurnal tides, the smaller (λ) is somewhat less than the value of the previous year, but is still between six and seven times the theoretical value. The mean of the two years agrees well with the mean values obtained at Moulmein and Rangoon; but is lower than at Dublat and Elephant Point, and much higher than at False Point.

The larger component (ν) is also less than the last year's value, and approaches nearer to the theoretical value; the mean of the two years agrees with the Dublat value, and is less than at Elephant Point and False Point.

The variational semi-diurnal tide (μ) has a proportional value this year not much greater than half what was obtained last year, and is about twice the theoretical proportion.

The solar elliptic semi-diurnal tides (R and T) have been deduced here for the first time this year (two years' observations being necessary). They both appear to be extremely large, R being 18 times the theoretical value and three times greater than has yet been found at any Indian port; whilst T is five times the theoretical value and twice as great as any value at any other port. These tides have not as yet been deduced for any other estuary port.

The luni-solar declinational semi-diurnal tide (R_2 of K), which last year shewed an abnormally high proportional value, has this year a proportional value nearly identical with theory, being 0·125 against 0·127.

The luni-solar compound semi-diurnal tide (2SM) is nearly the same as last year. Its proportional value agrees well with that of Dublat, but is much higher than at Elephant or False Point.

The diurnal tides, the sum of which last year only amounted to 28 per cent of the main tide, are this year only 24 per cent. All the several tides are nearly the same as last year, the reduction being in the solar diurnal tide, which last year reached the large proportion of 7 per cent of the main tide, and is this year only 2 per cent.

The proportions of P to O and J to Q are greater than theory gives, whilst that of O to K is less.

With regard to the over-tides of S and M, the quarter-diurnal of S is 4 per cent of the main tide, whilst that of M is 7 per cent, and R_6 of M is 2½ per cent. At Elephant Point it is 3½ per cent.

The quarter-diurnal Helmholtz's tide (R_4 of MS) is nearly 5 per cent of the sum of the two main tides.

The long-period tides at Amherst are all small, being the smallest in proportion to the main tides that have been found in the Bay of Bengal. Their total is only 18 per cent of the main lunar tide, agreeing in this most nearly with Port Blair, where they are 19 per cent. At Elephant Point and Dublat they are 25 per cent.

The solar annual is 10 per cent of the main tide. The epoch of its maximum effect is about the 21st August, which is the same time as has been found at Rangoon, Elephant Point, and Moulmein.

The solar semi-annual is only 3 per cent of the main tide. Its epochs are the 1st June and 1st December.

VALUES OF THE TIDAL CONSTANTS, PORT BLAIR, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Port Blair:—

Short-Period Tides.

	S	*M*	*O	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	4·718	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_1	0·018	0·012	0·156	0·388	0·137	0·029	0·026	.....	.....	.....	.....	.....	...	...	...	...
ϵ_1	34·84	1·69	224·46	48·38	236·79	41·23	162·77	.....	.....	.....	.....	.....	...	...	...	...
R_2	0·978	2·038	.....	0·271	.....	.....	.....	0·090	0·397	0·047	0·139	0·091	0·020	0·099	...	0·020
ϵ_2	313·49	275·38	.....	290·57	.....	.....	.....	94·98	270·98	129·00	252·44	293·96	67·06	81·74	...	170·36
R_3	.....	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_3	.....	8·17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_4	0·001	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·016	...
ϵ_4	85·60	124·12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	204·37	...
R_6	0·002	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_6	98·53	200·36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
R_8	0·002	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...
ϵ_8	87·61	61·93	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·018$ $\epsilon = 25°·71$
„ fortnightly „	...	...	$R = 0·061$ $\epsilon = 351°·00$
Luni-solar „ „	...	...	$R = 0·007$ $\epsilon = 6°\ 26$
Solar annual „	...	...	$R = 0·062$ $\epsilon = 132°·87$
„ semi-annual „	...	...	$R = 0·134$ $\epsilon = 196°·96$

The value of the mean level of the sea (A_0) above the zero of the gauge is rather less than last year, being 4·718 against 4·792.

The value of the amplitudes of the main tides of S and M is almost identical with what was found last year.

The proportion between the main tides is again very nearly the theoretical one, being 0·480 against 0·476 given by theory, the mean of the two years giving exactly the theoretical proportion.

The proportion between the smaller lunar elliptic semi-diurnal tide (R_2 of L) and the main tide is not so close to theory as it was last year, being ·044 against ·035; theory giving ·027.

The larger lunar elliptic tide (R_2 of N) is almost exactly the theoretical value, its proportion being 0·195; theory giving ·192.

With regard to the two lunar perturbational tides (λ and ν), they are much the same as last year; λ being about three times as great in proportion to the main tide as theory would assign, and ν nearly twice as great.

The variational semi-diurnal tide (μ) is the same as last year, and twice as great as the theoretical value.

The solar elliptic semi-diurnal tides (R and T) have been deduced for the first time this year (two years' observations being necessary).

With regard to the smaller component (R), its proportion to the main tide is 2½ times the theoretical value, which agrees well with what has been found at Madras and Vizagapatam; whilst the larger component (T) is about twice the theoretical value, which is what was found at Madras, but is considerably greater than at Vizagapatam.

The luni-solar declinational semi-diurnal tide (R_2 of K) approaches very nearly to the theoretical value, being 0·134 against 0·127; whilst at Madras, Vizagapatam, and False Point the values are rather less than theory gives.

The luni-solar compound semi-diurnal tide (2SM) is the same as last year, and has a proportion to the main tide about half what was found at Madras, and nearly the same as at Vizagapatam and False Point. As was found last year, the diurnal tides bear a very small proportion to the main lunar tide.

The solar declinational diurnal tide (R_1 of P) is the only one which has a slightly larger proportion than was found last year.

The lunar elliptic diurnal (Q) and the lunar declinational diurnal (O) are the same as last year, whilst the solar diurnal (R_1 of S), the luni-solar declinational (R_1 of K), the lunar diurnal (R_1 of M), and the lunar elliptic diurnal (R_1 of J), are less than last year.

The proportions of P to O, J to Q, and O to K, differ greatly from the values assigned by theory; the two former being much greater, and the last one much less. As was found last year, the lunar and solar over-tides are insignificant.

There is a close coincidence between the amplitudes of the short-period tides evaluated from the two years' observations, as might be expected from the position of Port Blair as an ocean port; and from this cause also the proportions of the various tides to the main lunar tide are more generally agreeable to theory than is usually found.

With regard to the long-period tides, the lunar monthly is nearly the same as last year, and insignificant in amount.

The lunar fortnightly has a value of 3 per cent of the main tide, which is the same as was found last year. The luni-solar fortnightly is hardly appreciable.

In the solar annual tide there is a considerable difference both in amplitude and epoch from the values of last year. This year it is only 3 per cent of the main tide, which is nearly the smallest value which has ever been obtained for an Indian port, the only values at all approaching to it being at Kurrachee and Bombay. Its time of maximum effect is the 4th August. Last year it was early in September.

With regard to the solar semi-annual tide, its proportion to the main tide is ·066, which is about one-fifth what was found at Madras and Vizagapatam, and agrees nearly with the proportion at Dublat and Elephant Point. Its times of maximum are about the end of June and December, or about a fortnight later than was found last year.

Memorandum by Major M. W. ROGERS, R.E., *Deputy Superintendent, 4th grade, on the earthquake of the 31st December* 1881 *and the great sea-waves resulting therefrom, as shown on the diagrams of the tidal observatories in the Bay of Bengal.*

PORT BLAIR mean time is used throughout. Latitude 11°40′30″ N., longitude 92°45′ E.

The tide-wave can be traced clearly on the diagrams at seven tidal stations, viz. Port Blair, Paumben, Madras, Negapatam, Vizagapatam, False Point, Dublat, and may be suspected on an eighth, viz. Diamond Harbour, on the Hooghly.

At Port Blair, in the Andaman Islands, the first indication of the shock is at 7h. 42m. A.M., and this, I am inclined to think, is due to the earth-wave, or rather to the forced sea-wave, which is formed when the earth-wave gets into shallow water; for the tidal curve goes on undisturbed for some 30 minutes afterwards, and it is not until 8h. 10m. A.M that the first wave is recorded, followed by others in succession at about 15 minutes' interval, with a height of about 3 feet from crest to hollow. The diagram is unfortunately incomplete, for the pencil of the gauge, in its violent oscillations, caught in and tore the paper of the diagram, and the clerk, being frightened, stopped the driving clock, which was not started again until 1 P.M. There is evidence that the waves continued to follow one another with great regularity until about 3 P.M., when they became of a much smaller size, but are traceable until 9 P.M. Small shocks were felt on Ross Island all that day, and the violence of the great shock, which damaged the barracks and did other injury, seems to indicate that the centre of impulse could not have been far from the Andamans.

At Madras there is a trustworthy time for the advent of the earth-wave; it is obtained from the Telegraph Office, where the shock affected the recording instruments. It occurred at 7h. 56m. A.M (7h. 5m. 45s. Madras time), whilst the great sea-wave reached at 10h. 10m. A.M., and continued until 7 P.M., with intervals of about an hour from crest to crest, and the influence of the disturbance can be traced until 10 P.M.

At Negapatam the first and largest wave came in at 10h. 10m. A.M., with a height of nearly four feet from crest to hollow, and it was succeeded by a series at about half-hour intervals, which continued until midnight. Judging from the diagrams, the sea at this port seems to have been more affected by the earthquake than at any other.

At Paumben the first wave was registered at 11h 35m. A.M., and was followed until midnight by a succession of waves with about two hours' interval between them.

At Vizagapatam the first wave was recorded at 10h. 48m. A.M., and from that time there was a succession of small waves at irregular intervals until past midnight.

At False Point the diagram shows the passage of the earth-wave or forced sea-wave at 7h. 54m. A.M. The pencil seems to have been moved rapidly up and down a small quantity for some minutes, and the clerk notes that the building was shaken by an earthquake. The sea-wave here is hardly indicated. Its first appearance is at 11h. 12m. A.M., and there is a second one at 1 P.M.

At Dublat the wave appears to have arrived at 1 P.M., and a second, one hour afterwards; there is also an indication of a third at 3 P.M.

At Diamond Harbour the indications of the wave are untrustworthy, and very slight. If felt at all, it was at about 3 P.M.

Looking over the data at our disposal, I find that the shock, *i.e.* the earth-wave, was recorded as felt at Madras, Coconada, Vizagapatam, Gopálpur, False Point, Calcutta, Port Blair, and Kisseraing, an island in the Mergui Archipelago in latitude 11°39′ N., longitude 90°31′ E., and also on board a ship, *The Commonwealth*, in latitude 5°55′ N., longitude 92°49′ E.

Of these the times of the shock at Madras, False Point, and Kisseraing were probably recorded correctly within a minute. Madras was recorded in the Telegraph Office, and given to the nearest second; False Point was recorded on the tidal diagram, and also by Mr. Rendell, of the Survey, who was leveling a few miles from False Point, and whose recorded notice of the time at which he felt the shock agrees to the minute with the tide gauge record.

At Kisseraing I was observing at the trigonometrical station there with a 24″ theodolite, and saw the earthquake before feeling it; the heliotrope (distant some 15 miles) to which I was observing appearing to rise and fall in the field of the telescope, and the levels of the instrument being violently agitated. The motion was, to my feeling, barely perceptible, but the recorder and other men with me said that they felt it distinctly. It was not, however, felt by several of the officers of the Indian Marine, who were on the island that morning, thus proving that it was not a severe shock, though plainly noticeable by instrumental means.

At Madras, False Point, and Kisseraing, the earth-wave was felt at about the same minute—7h. 55m. A.M. On the hypothesis that the strata between them and the centre of impulse is homogeneous, this centre was equidistant from them, and would be at a spot in the Bay of Bengal in latitude 11°55′ N. and longitude 89°33′ E.

There is no reliable evidence on the subject of the velocity of earth-waves; it varies with the nature of the strata through which it passes and the violence of the initial shock, and also on the depth of the locus of the centre of impulse.

If we assume that the centre of impluse in this case was at the point mentioned, it will be found that it, and Port Blair and Kisseraing, are almost in a straight line. The distance from Port Blair to Kisseraing is 400 miles; and if we assume that the mark on the diagram at the former place at 7h. 42m. was due to the earth-wave, it took 13 minutes to travel 400 miles, which gives a rate of 30 miles per minute—a velocity which I find mentioned in books on the subject as probable under favourable circumstances. With this velocity the central shock should have taken place at 7h. 35m., the distance to Madras, &c., being a little over 600 miles. The distance from this assumed centre of impulse to Port Blair is 218 miles, which would take seven minutes in transit and cause the shock to be felt there at 7h. 42m.

This fixing of the locality of the centre is of course merely hypothetical: the whole of the region is volcanic. Narcondam and Barren Island, to the east of the Andamans, are volcanoes, the latter having been in eruption as late as 1792; the only thing certain is that the centre must have been not far from Port Blair and Car-Nicobar, and about equidistant from the whole of the east coast of the Bay of Bengal, and also it must have been subaqueous in order to have caused such distinct tidal waves.

All the times of the earth-wave reaching places on the west side of the Bay agree very fairly; but in all the cases except those mentioned, the times are not likely to be sufficiently accurate to aid in the investigation.

The force of the earthquake was great at Port Blair, where it did damage to the barracks, &c., and at the Island of Car-Nicobar it was felt severely, the huts of the natives and many of their palm-trees being thrown down.

Several slight shocks were felt at Port Blair on the same and the two succeeding days, and *The Commonwealth*, which, as mentioned, felt the shock of the 31st, felt three shocks

again on the 1st off the Island of Car-Nicobar. All this points to there having been considerable subterranean disturbances in those regions at that time.

I can find no trustworthy indication of the direction of the motion as felt at the various places. At Madras there are three estimations of it: one north to south, and two others north-east to south-west; whilst the clerk of the tidal observatory says that there were two shocks—the first north to south and the second east to west. Mr. Rendell, at False Point, states that the direction appeared to him to be from north-west to south-east, whilst a person at Calcutta says that it appeared to go from west to east. At Kisseraing Island the motion was so slight that I could not decide on any direction. My first impression was that it came from the west, but after careful consideration I could not decide sufficiently satisfactorily to place it on record.

The great tide wave, of which we have full evidence on the tidal diagrams, was felt, as was to be expected, a considerable time after the shock, varying with the distance and other causes, such as wind and its velocity of translation, which again varies with the depth of the water at any given point.

The wave reached Port Blair first at 8h. 10m., or, if we assume the foregoing idea of the locality of the centre of disturbance and time of the original shock, in 35 minutes, with an average rate of 6·2 miles per minute. It reached Madras and Negapatam at 10h. 10m., two hours later than Port Blair. These places are 614 and 640 miles from the assumed centre, and would give a velocity of 4 miles per minute.

At Paumben the first wave came in at 11h. 35m., or more than one hour later than Negapatam; but owing to the intervening land and straits, I do not think any estimate of velocity can be made. At Vizagapatam the wave reached at 10h. 48m., about 40 minutes later than Madras, giving a velocity of 2·9 miles per minute. At False Point the wave reached at 11h. 12m., or 24 minutes later than at Vizagapatam, giving the same velocity of 2·9 miles per minute. The wave reached Dublat at 1 P.M., giving a velocity of a little over two miles per minute.

The direction of the wind all day was N.N.E., which would tend to reduce the velocity of the wave on its road to the northern ports.

Extract from the Narrative Report, dated 22nd December 1882, *of* LIEUTENANT-COLONEL W. M. CAMPBELL, R.E., *Deputy Superintendent, 2nd grade, in charge No.* 1 *Astronomical Party.*

I ARRIVED at Mussoorie, on return from furlough to Europe, on 15th May 1882, and took charge of No. 1 Astronomical Party in the place of Major Heaviside, who had proceeded on furlough. Major Strahan having written a general report regarding the longitude operations carried out during season 1881-82 by the two Astronomical parties combined, I need not here allude to the movements of No. 1 party, under Major Heaviside, in the field.

I found the work in a fairly forward state as regards the reduction of the observations, and it was steadily proceeded with until completed in October.

A large portion of my own time was employed in going through the reductions of the previous season's work, viz. 1880-81, with the hope of finding some source of error, the correction of which would improve the accordance of the results obtained. In this I was unsuccessful, and my investigations throw no light on the origin of the discrepancies, the magnitude of some of which had caused me much surprise and some uneasiness.

I did make some minute alterations in the method of computing the level corrections applied to the star observations, and, curiously enough these in almost every case increased the closing error of the triangular circuits, which seems to indicate that a coincidence within 0"·01, or 0"·02, in the values of an arc of longitude obtained by direct measurement and by the sum of two other arcs is very fortuitous. Much of my time was also occupied in supervising the printing of the results of 1880-81, which was carried on, and nearly completed, during the recess.

As regards the results obtained from the observations of 1881-82, these are, I regret to say, very unsatisfactory. The discrepancies between the individual values of each arc are generally larger than in former seasons, and two out of three circuit errors obtained are of almost incredible magnitude.

The observations taken for collimation throughout the season showed an amount of instability in that adjustment in the case of both telescopes, but more particularly with regard to No. 2, which was used by Major Strahan, which has caused me great anxiety as to the results from the time when I took charge of the reductions; but the event has far exceeded my worst anticipations.

When the bad results became apparent, suspicion was first thrown on the methods of observation and reduction; but the work has been gone through without any success in detecting mistakes of procedure, and all the evidence points out that the instruments are to blame. The instability of the collimation adjustment, already remarked upon, might perhaps be held sufficient to account for the errors found, were it not for the fact that the system of reversing the instruments, which has always been carried out, must eliminate from the resulting value of each arc the effects of all instrumental defects which are constant; and it is difficult to imagine inconstancy, in any hypothetical source of error, sufficient to leave such gross discrepancies in spite of the tendency of the system to cancel its effects.

The inconstancy of collimation pointed to the conclusion that the fault in telescope No. 2, which was successfully treated at Madras in 1875, had reappeared in that telescope, while No. 1 was affected to some degree by a similar failing; but the collimation observations recorded during the season do not suffice to enable me to speak with absolute confidence on this point. During the recess both the telescopes were examined by Mr. Bolton, who reported that there was great weakness of both in the suspected parts, viz. the junction of the object-half of the telescope tube with the flange, by which it is attached to the axis. These parts were accordingly thoroughly strengthened by the addition of internal collars and new soldering, and the same treatment was applied to the corresponding parts of the eye-end tubes. I am glad to say that both instruments have since then given satisfactory evidence of stability in the collimation adjustment, and I believe they are now in a better condition than they have been at any former time.

In case of the reappearance of any such defects as have on former occasions been found in these telescopes, it may be advisable to record here my experience in the matter, which, as regards these individual instruments, is greater than that of any one else.

In the first place, I consider that all observations for collimation should be carefully carried out in a way calculated to show up any instability which may exist in that adjustment, and so long as these observations afford no evidence of such instability the telescope may be used with confidence, but if any symptoms of inconstancy of the collimation adjustment should appear, suspicion should be at once aroused.

The most crucial test of stability in this respect of which I am aware is to obtain two determinations of collimation error; one from readings of horizontal collimators taken after the instrument has been pointed towards the zenith, and the other from similar readings after pointing towards the nadir. A slight difference between these two values may always be expected, as they are obtained after subjecting the telescope to two sets of strains of exactly opposite effects, and no instrument can be absolutely perfect and free from yield to such strains. The amount of difference in this respect which should be looked upon as sufficient to condemn the telescope must remain a matter of judgment and experience. If repeated experiments should show that, although somewhat large—say three divisions of the micrometer = 1″—it is very constant, the telescope may be continued in use, because the effects of all constant errors can be eliminated by reversing the telescope in its Y's; but as soon as irregularity in the amount, or sign, of the difference occurs in any marked degree, the telescope had better be carefully examined, and should remedies practicable on the spot—such as screwing the parts together more carefully, which I have known to be efficacious on one occasion—prove insufficient, it must be sent to an instrument-maker for repairs.

I would very strongly urge that every determination of collimation error taken during observations should show two distinct values obtained as above described, one for the zenith and the other for the nadir position, and that, if there should be a sensible constant difference between them, the former should be employed for correcting the transits of stars, and the latter should be used in combination with the mercury observations for finding the dislevelment of the instrument.

In order to afford the means of testing the constancy of the line of collimation in all positions of the telescope, I designed a frame to carry a small reflector permanently in front of the object glass, so that, by using a Bohnenberger eye-piece, a reflection of the wires might be observed in any position.

This reflector must not be large enough to interfere with the ordinary use of the telescope for star and collimation observations, because, unless it can be kept permanently in position on the telescope, its chief advantage will be lost, and from experiments already made I fear that a reflector of suitable size may not give sufficient light to afford an image fit for observation.

If a larger reflector were employed, and only applied to the telescope at certain times, when wanted for use, the difficulty of mounting and adjusting it securely would be immensely increased; and it need hardly be remarked that the slightest uncertainty in this respect would vitiate the whole principle, because if the reflector be subject to any accidental change of plane, relatively to that of the object glass, it will give false and misleading results.

On this point I feel considerable doubt as to the success of the contrivance, even in the case of a small reflector permanently in position; but as in that case its readings could be compared with those of the collimators, and of the mercury reflections, such changes would probably be detected.

If such an adjunct could be perfected, it would be a valuable addition to an astronomical instrument, even more so in the case of one for observing altitudes which is directly affected by flexure in a vertical plane, than in the case of a purely transit telescope, where such flexure is of no consequence, except in its indirect effects, which may take place in other planes.

Extract from the Narrative Report of MAJOR G. STRAHAN, R.E., *Deputy Superintendent, 2nd grade, in charge No. 2 Astronomical Party, for the season ending 31st October* 1882.

IN accordance with instructions received from you I proceeded to Agra, after having made over charge of the Mysore Topographical Survey to Major Thuillier, to meet Lieutenant-Colonel Campbell and Major Heaviside there, from the former of whom I was to receive charge of the instruments, office records, and camp equipment of No. 2 Astronomical party,

and to gain some further insight into the details of the longitude work before his departure on furlough. I arrived in Agra on October 27th, and spent twenty-seven days in examination of, and petty repairs to, the instruments and field equipment of the party, and some preliminary practice with the apparatus, including the determination of personal equation between myself and Major Heaviside. The charge of the party was made over to me by Colonel Campbell on November 4th.

On November 20th Major Heaviside started for Fyzabad to commence the measurement of the first arc, Fyzabad–Agra.

The arcs measured during the season were as follows :—

		Observers.	Commenced.	Completed.
1.	Fyzabad ... ... Agra	Major Heaviside ,, Strahan.	... November 25th	... December 2nd.
2.	Fyzabad ... ... Jubbulpore	Major Heaviside ,, Strahan.	... December 12th	... December 20th.
3.	Hazaribagh ... ... Fyzabad	Major Strahan ,, Heaviside.	... January 4th	... January 10th.
4.	Hazaribagh ... ... Jubbulpore	Major Strahan ,, Heaviside.	... January 19th	... January 26th.
5.	Calcutta ... ... Hazaribagh	Major Heaviside ,, Strahan.	... February 8th	... February 16th.
6.	Jalpaigori ... ... Hazaribagh	Major Heaviside ,, Strahan.	... February 25th	... March 5th.
7.	Jalpaigori ... ... Calcutta	Major Heaviside ,, Strahan.	... March 17th	... April 6th.

Observations for personal equation were taken, besides those at Agra already mentioned, at Fyzabad, Hazaribagh, and Jalpaigori, the results of the four observations being as follows :—

	By North Stars.		By South Stars.	
At Agra in November ...	S—H = —0·014	prob. error ±·012	S—H = —0·005	prob. error ±·013.
,, Fyzabad in December...	S—H = 0·000	,, ±·010	S—H = +0·037	,, ±·009.
,, Hazaribagh in January	S—H = —0·032	,, ±·006	S—H = —0·015	,, ±·007.
,, Jalpaigori in March ...	S—H = —0·006	,, ±·007	S—H = +0·027	,, ±·006

The process by which these values were obtained was the usual one in which one observer notes the transit of a star over the first 10 wires, and the other observer over the last 10; reduction to the central wire then gives the equation at once. About 80 stars were taken at each place for this purpose. The capital letters S. H. refer to the observer's initials. For the first two arcs, the mean of the November and December values was used ; for the third and fourth, the mean of the December and January values ; and the fifth, sixth, and seventh arcs, the mean of the January and March values.

It occurred to me during the work that there might possibly be an eye equation depending on whether the right or left eye was used for observing, and while at Hazaribagh I took divided transits of about 80 stars to ascertain this point. The reduction of these shows such an equation to be inappreciable, but it brought to light most unmistakably the fact that when a star is observed over a number of wires (15 or 20) there is a marked tendency to anticipate the transit over the latter half of them, *i.e.* that the mean of the former half, when reduced to the central wire, gives a later epoch than the mean of the latter half. A little consideration will show that the effects of this peculiarity are taken into account when the differences of transits by the two observers are taken out and corrected by the application to them of their relative personal equation ; for it may be considered as a personal error pecular to the individual in estimating the time of a transit. The peculiarity is brought into play exactly in a similar manner in the observations for personal equation and in star transits, and its annihilation would be theoretically perfect if the same number of wires were observed in both processes. This is not strictly the case, as ten or twelve are used in the former and any number from one to fifteen (fifteen in a large majority) in the latter. The whole effect is however so small, and was moreover recognized only by the observation of twenty wires, that this departure from theoretical accuracy may be considered as quite immaterial.

There is little to notice in the way of novelty in the procedure during the past year. One change that was discussed and sanctioned at Agra during your visit there in November was made, viz. an alteration in the system of changing pivots. Up to that time the pivots had always been similarly placed at both stations, either both I. P. E. or I. P W. (the initials I. P stand for illuminated pivot), the change from one to the other being made after the first half of the observations was completed. The new method (which was applied to alternate arcs only, viz. the 1st, 3rd, 5th, and 7th) consists in placing the pivots dissimilarly, *i.e.* I. P. E. at one station and I. P. W. at the other, both being changed as before after the first half of the observations. Theoretically one system cancels pivot error as effectually as the other, but it was hoped that some light might be thrown on some supposed pivot irregularities by this process. The number of observations, however, is not great enough for the purpose, besides the effects of any such irregularities are masked by other errors to be noticed below.

The direct comparison of clocks and deduction of the difference of their errors by the observation of what we have termed "local groups" (in contradistinction to "longitude groups," and so called on account of the local clocks being used by both observers) was never omitted, so that on every night there exist two separate methods of determining the difference of longitude; the one, by noting the time elapsed during the passage of a group of stars (the same for both observers) from the meridian of the eastern station to that of the western, by each clock alternately, and the other, by the direct comparison of clocks alluded to above. The agreement of the results of two methods is remarkably close, the mean difference being only ·012 sec. Both systems had been in use previously, but the latter had never been made an integral part of each night's programme before this season, or rather it would be more correct to say that the deductions of the latter had never been fully worked out for each night, because of so much extra labour being necessary for that purpose. The importance, however, of thus securing two partially independent values of each arc was so strongly urged by Lieutenant-Colonel Campbell that means were taken to secure them, and experience has shown that the additional labour of observing and reducing caused thereby is not so great as was anticipated.

It is with much regret that I have to report that, notwithstanding all the care that was bestowed on the work down to the minutest detail, the result of the season's work, as tested by the closing of the circuits, is not satisfactory.

In investigating the cause of these circuit errors all possible sources of error exceeding twenty in number were each discussed one by one, and a brief *resumé* of the results was submitted to you shortly after these discrepancies first came to light. The cause has been proved quite conclusively to my own mind to lie in uncertain flexure or shake of some kind in the telescope tube. This conclusion is almost forced on one by three separate considerations: first, because systematic reversal of pivots, pens, clocks, &c., makes it impossible that errors of this kind and amount can have their origin in any other source; second, because there is an *à priori* probability of its being caused by an imperfection in the tube, as a similar imperfection had been brought to light and remedied in a previous season's work; and thirdly, because there is no security that the line of collimation, when the telescope is pointed to the zenith, or near it, for the observation of transits, remains in the same relative position to the axis as when the telescope is placed horizontal or pointed to the nadir, as it unavoidably is in collimating and leveling respectively. During the recess both telescopes have been overhauled and the tubes strengthened, and various small changes, merely for the convenience of the observer, which it is unnecessary to particularize, were made.

The causes of, and remedies for, these instrumental defects have been so minutely considered and discussed by yourself and Colonel Campbell, with me in person, that it is perhaps unnecessary to enlarge upon them here, and I will only add that the repairs have been tested, as far as possible, by methods which on a previous occasion have shown similar faults to have been remedied. Some slight changes in the routine are to be adopted in future to guard, as far as is possible, against such faults coming into play again unnoticed. One suggested by Colonel Campbell seems to be an excellent safeguard, and is as follows:— In collimating, the telescope is supposed to begin from the nadir position; it is then to be raised twice to the north collimator and micrometer readings taken (suppose the mean = P). It is then raised to the zenith and twice depressed to the north collimator, giving a mean reading Q. The same process is then repeated with the south collimator giving mean readings R and S. Now if the telescope were perfect, the following equations would hold: $P=Q$ and $R=S$, but practically no instrument can be made so perfect as exactly to fulfil these conditions; but the nearness or otherwise of their fulfilment is a good test of the stability of the tube. Colonel Campbell then proposes that the value of collimation $\frac{1}{2}(P+Q)$ should be used when determining the level correction by mercurial reflection, and $\frac{1}{2}(R+S)$ for computing the correction for collimation for the transits of longitude stars. The difference between the two would be quite inappreciable while the instruments were perfectly stable, whereas if they are not, the result would be more theoretically correct than by using $\frac{1}{4}(P+Q+R+S)$ both for level and for longitude stars as has hitherto been the practice.

It is proposed also to change pivots each night, and also during the first arc to observe for eight nights instead of six.

The chronographic and electrical parts of the apparatus worked well, with some trifling exceptions, and seem to admit of no further improvement. Some experiments were made to ascertain how far the adjustment of the various relays and armatures affected the retardation, but no definite results were afforded by the observations, except the conclusion that any corrections due to this cause were rejectaneous; they remain, however, permanently recorded on the chronograph sheets for future reference if required.

The programme for the season 1882-83 will commence with the arc Jalpaigori–Fyzabad, which will, when completed, be approximately computed. This, with the help of all three observers, Lieutenant-Colonel Campbell, Major Heaviside, and myself, will probably not take more than two or three days. The arcs to be next undertaken will partly depend on the results of this one. Chittagong–Jalpaigori and Chittagong–Calcutta seem the most desirable, then Calcutta–Fyzabad and Calcutta–Jubbulpore, and what time then remains should be spent in revision of some of the arcs about Agra to be subsequently decided on. By leaving the western arcs to the last, it will be possible to work later in the season, as the weather up-country remains favourable for such observations long after the sky in Bengal becomes overcast.

GEOGRAPHICAL COMPILING AND DRAWING BRANCH, SURVEYOR-GENERAL'S OFFICE, CALCUTTA.

Statement showing the nature of the work performed and the progress made from 1*st October* 1881 *to* 30*th September* 1882.

Maps.	Scale. In. Mls.	Remarks and Progress.
India	1 = 96	Revisions, &c., on engraved proof for new edition.
India (outline map), 4 sheets ...	1 = 64	Additions, territorial names, &c. (from recent surveys), inserted for Engraving Branch.
India (with hills), do. ...	1 = 64	Hills in brush shading completed.
India (preliminary edition), 6 sheets	½ = 32	Hills completed, and additions made for second issue.
India 6 sheets engraved, final ...	1 = 32	Additions (names—Railways—new materials for Afghanistan, &c.) for engravers.
Rajputana Agency, 2 sheets ...	1 = 16	Compilation completed from surveys made up to date.
Central India Agency, 2 sheets ...	½ = 16	Compilation completed up to date.
Central Provinces, 4 sheets ...	1 = 16	Brush shading of hills completed on proof sheet for Lithographic Branch.
Bengal, Behar, Orissa, and Chota Nagpore (with hills), 2 sheets.	1 = 16	Railways inserted, names corrected, and marginal lines adjusted.
Sketch map of the Hazarajat ...	½ = 16	Hill drawing completed for photozincography.
Punjab, 4 sheets	1 = 16	New compilation, embracing all recent surveys to date. Sheet No. 4 completed.
Nizam's dominions, 2 sheets ...	1 = 16	Drawing in outline finished, printing of names, &c., in progress.
North-Western Provinces (edition of 1875), 4 sheets.	½ = 16	Revised to date.
Berar (Hyderabad Assigned Districts), 1 sheet	1 = 8	Hill drawing completed.
Pishin and Sibi	1 = 8	Compilation completed.
Punjab (edition of 1875), 8 sheets	1 = 8	Revised to date.
Bengal (edition of 1875), 16 sheets with index.	1 = 8	Ditto.
Southern Afghanistan, 2 sheets ...	1 = 8	Compilation completed.
Singhpo-Kampti country, or neutral ground between India and China, 2 sheets.	½ = 16	Prepared for Mr. C. H. Lepper. Compiled from various sources for reduction to ½ scale.
District Maps.		
Bannu	1 = 4	Compilation completed.
Dera Ishmail Khan	1 = 4	Ditto in progress.
Peshawur	1 = 4	Ditto completed.
Dera Ghazi Khan	1 = 4	Ditto ditto.
Raipur	1 = 4	Extracted from the sheets of the Atlas of India; revised and completed to date for publication.
Sibsagar	1 = 4	
Nowgong (Assam)	1 = 4	
Goalpara	1 = 4	
Sylhet	1 = 4	
Darrang	1 = 4	
Kamrup	1 = 4	Extracted from the sheets of the Atlas of India, and in course of completion.
Balaghat	1 = 4	Completed for publication of second issue of map.
Special Maps.		
District Shahjehanpore ...	4 = 8	Drawn for the Gazetteer, North-Western Provinces.
Ditto Dehra-Dun	1 = 8	
Ditto Terai	1 = 8	
Ditto Moradabad	1 = 8	
India	1 = 128	Completed for Geological Survey.
Do.	1 = 128	Ditto Meteorological Report.
Do.	1 = 64	Showing hot springs; names inserted.
North-Western Provinces ...	1 = 32	Tahseel boundaries and other additions inserted for Census Department.
Bengal and Assam	1 = 64	Division and district boundaries corrected and brought up to date for Census Commissioner.
Khasia and Garrow Hills Survey, Extract from Sheet No. 84.	1 = 2	Hill shading completed for Geological Survey.
Chart of the coast of India ...	.....	Coast line enlarged to double scale, and names inserted for Postal Department.
Punjab (to illustrate Administration Report for 1881-82.)	1 = 32	Revised and brought up to date for Punjab Government.
Lower Egypt. (Based on E. A. Goujon's map.)	1 = 3·1565	Blue prints outlined, and corrections made from information supplied by the Quarter-Master-General's Department for reduction to ½ scale.
Suez Canal. (From Charts of the Suez Canal Company, 1876.)	.....	Blue prints outlined, and names, &c., typed for reduction to ¼ scale.

GEOGRAPHICAL COMPILING AND DRAWING BRANCH, SURVEYOR-GENERAL'S OFFICE, CALCUTTA.

Sheets of the Atlas of India, 1 inch = 4 miles.

13 N.E.	Part of Junagarh	Hills drawn and footnotes completed.
14 N.E. S.E.	Part of Hazara	Compilation on dry-print in progress.
18 N.E.	Part of Bhawalpur native states	Reduction from recent surveys.
19 S.E.	Part of Rajputana	Ditto.
20 N.E. S.E.	Ditto	Ditto and hill shading by brush.
28	Hazara	Compilation on dry-print in progress.
29	Rawalpindi, &c.	Additions and large lettering completed.
30	Parts of Gujranwala and Amritsur.	Insertion of railway-station names and minor details.
31 N.W. S.E.	Part of Bickaneer	Reductions from recent surveys and additions.
32 N.W. N.E.	Ditto	
35 S.E.	Part of Indore	Hills drawn in brush for engraving.
36 N.W.	Ditto	Reductions from recent surveys.
S.W.	Rajpipla State	Correction of boundaries and names.
37 N.W.	Ditto and Khandesh ...	Ditto in progress.
N.E. S.E.	Parts of Khandesh	Insertion of boundary (Holkar concession boundary).
38 N.W. S.W.	Parts of Nasik, Ahmednugur and Poonah.	Compilation on dry-print in progress.
N.E.	Part of Hyderabad territory ...	Drawn in outline from existing materials.
39 40	Parts of Poonah, Ahmednuggur, and Puriandah, and part of Satara.	Reduction from Deccan survey.
48 N.E.	Part of British Garhwal ...	Details inserted from new survey of Dehra Dún.
S.E.	Part of Mozuffernugar, &c. ..	Reduction from surveys.
49 S.W.	Parts of Ulwar and Jaipur ...	Additions and details from recent surveys.
N.E. S.E.	Parts of Delhi	Reductions from recent surveys in progress.
50 N.E. S.E. N.W.	Parts of Mutra, Gurgaon, and Agra	Ditto ditto.
54	Part of Hyderabad	Insertion of Holkars boundary.
56	Parts of Barsi and Naldrug ...	Revision of old work according to recent surveys from Deccan Topographical survey.
67 N.E. N.W. S.W.	Parts of Bareilly, Rampur, Budaon, and Moradabad.	Heights inserted.
71 S.E.	Parts of Mandla and Seoni	Hills drawn in brush for engraving.
76 N.E.	Nellore Guntur	Original drawing received from Superintendent, Madras
78 N.E.	Arcot	Revenue Survey, examined.
103	Part of Behar	Corrections of the old courses of the Ganges, Gogra, and Gandak rivers.
108	Part of Vizianagram	Hill shading in brush for engraving.
112	Parts of Munghir and Patna ...	Resurveys of the Ganges and Gogra rivers, inserted in outline.
114 115	Parts of Chota Nagpore and Bengal	Inserting canals.
116	Part of Orissa	Insertion of additional details and revision.
118	Part of Darjeeling	Hill shading.
138 S.W.	Part of Eastern Frontier of Assam.	Additions in sketch work about the Nougyong Lake, Patkai range.

Standard sheets of the Topographical Branch Survey of India, drawn for reproduction.

Maps.	Scale. In. Mls.	Remarks and Progress.
Chota Nagpore Survey.		
Sheets 39, 40, 45, 46, 47, 57, and 59	1 = 1	
Khandesh and Bombay Survey.		
Sheets 4, 14, 15, 16, and 17 ...	1 = 1	Revising boundaries, railways, and otherwise bringing the sheets up to date for reproduction for second issue.
Rewah Survey.		
Sheets 22, 23, and 24	1 = 1	
Rajputna Survey.		
Sheet 23	1 = 1	

GEOGRAPHICAL COMPILING AND DRAWING BRANCH, SURVEYOR-GENERAL'S OFFICE, CALCUTTA.

Miscellaneous Maps, Tracings, &c.

Maps.	Scale.	Remarks and Progress.
	In. Mls.	
Sadiya Cantonment	12 = 1	Drawn on vellum cloth for reproduction.
Plan of Calcutta	6 = 1	New buildings and names inserted.
Plan of the Sanitarium of Simla ..	3 = 1	Hill shading in vertical completed.
Plane-table sections of the Khandesh and Bombay survey ...	1 = 1	Revised boundaries inserted.
Chart of the Triangulation of the Mysore Topographical survey ...	1 = 4	Points plotted, names of stations inserted, revised and corrected, work previously plotted.
Postal map of Central India ...	1 = 32	Drawn on vellum cloth for Post-Master-General, Central India.
Map showing area occupied by Bihari dialect, Lower Provinces	.....	Insertion of boundary and names for Magistrate of Patna.

Miscellaneous Maps, &c., concluded.

	In. Mls.	
Sketch map of the country from Sherdurra to Mulka traversed by Eusofzai field force ...	1 = 2	Trace on vellum cloth prepared.
Designs of almirahs for type ...	3 copies. About	Tracings prepared on vellum cloth for the use of Executive (survey) officers.
City and environs of Kandahar ...	6 = 1	Corrections made in original as given in proofs (by Colonel Leach).
Sketch map of the Hazarajat ...	1 = 16	Prepared according to Colonel Leach's directions.

847 sheets of various engraved, lithographed, and photozincographed proofs, examined, corrected, or added to for publication in a complete form for office use and for issue.

W. H. PATTERSON,
Surveyor, 1st grade, Survey of India, and Chief Draftsman.

JOHN O. N. JAMES,
Assistant Surveyor-General, In charge Drawing and Geographical Compiling Branch.

WORK DONE BY THE EXAMINING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

Subjects examined	Original standard sheets, large scale plans, and triangulation charts of Topographical Surveys	58
	Original compilations of parts of atlas sheets and other maps compiled in Surveyor-General's office	25
	Engraved proofs in outline and names, &c., in various stages, as well as of general and provincial maps	138
	Photographed and lithographed proofs on various scales, including maps, plans, atlas sheets, &c., together with additional work of corrections in territorial changes and public constructions, such as boundaries, canals, roads, &c.	469
Hill shading in brush and pen	Atlas sheets in brush, and maps in pen work	4
Work compiled	Portions of atlas sheets and provincial maps, &c.	2
Projection of graticule ...	Projection of atlas sheets, and district and provincial maps ...	13
Miscellaneous	Tracings of sketches, charts, and supply of geographical data to various officials, computation of graticule for the plates of the Indian Atlas and projection of the same on copper, calculation of areas, &c.	

A. CHAMARETT,
Surveyor, Examining Branch.

JOHN O. N. JAMES,
Assistant Surveyor-General, In charge Drawing and Geographical Compiling Branch.

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

General Maps, &c.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
	Sq. in.	Letters cut.	Sq. in.	
Map of India, scale 1 inch = 32 miles—				
Sheet 3	.....	10,705	.....	Heavy additions to outline, railways and lettering for 2nd edition.
,, 4	.....	5,350	.....	Revised and added to for 2nd edition; finished.
,, 5	.....	5,270	27 H.	Plate in hand; hills in progress.
,, 6	.....	2,929	.....	Revised and added to for 2nd edition; finished.
Map of India in four sheets, scale 1 inch = 64 miles ...	.....	13,458	196 H.	Additions and corrections done; hills in progress.
Map of India in two sheets, scale 1 inch = 80 miles ...	.....	45	.....	Slight additions; plate put down.
Map of India, scale 1 inch = 96 miles	.....	40	.....	Ditto ditto.
Map of Bengal in two sheets, scale 1 inch = 16 miles ...	50	9,284	.....	Outline taken out, corrected and engraved; plate put down.
Map of Central Provinces in two sheets, scale 1 inch = 16 miles	.....	.....	217 H.	Slight corrections to outline and writing; hills in progress.
Map of Rajputana in two sheets, scale 1 inch = 16 miles	47	1,782	66½ H. 25 S. H.	Additional outline engraved; writing in progress
Map of Central India Agency in two sheets, scale 1 inch = 16 miles	.....	.....	109 H.	Hills in progress.
Map of Assam, scale 1 inch = 16 miles	39	3,460	.....	Large portion of old work taken out; new outline engraved.
Chart of the Indian Ocean ...	.....	266	.....	Additional writing.
Map of Himalayan Routes ...	140	40	.....	New outline; plate in progress.
Map of Berar	320	288	.....	Plate projected, border cut and outline done; plate in progress.
Map of India, No. 2	.....	.....	.....	Corrections and additions done.
Index Chart to G. T. Survey	.....	340	.....	Additions and corrections done.
Strange's Zenith Sector. Frontispiece	.....	41	.....	Highly finished.
Strange's Zenith Sector, five other plates	.....	1,837	.....	Plates 3 and 5 finished; others, outline nearly finished.
Transit Telescope ...	.....	292	.....	Plate nearly finished.
Idiometer (Machine) by Colonel Campbell	.....	192	.....	Additional writing.
Chronograph	.....	441	.....	Plate nearly finished.
Commutator Board, plate 3 ...	.....	.....	.....	Outline finished.
Graticule plate (brass) ...	.....	.....	.....	Outline and writing done.
Major Waterhouse's reproduction in heliogravure 27A S.E.	.....	450	.....	Title and imprint finished.
Ile de Capraia	.....	199	.....	Plate finished.
Geological specimens, 2 plates	.....	804	.....	Finished.
Tint No. 1, 21¾″ × 13″ ...	.....	...	.....	Ruled and finished.
Tint 22″ × 18″ ...	.....	.....	.....	Ruled in $\frac{1}{10}$″ divisions; finished.
Three imprint plates ...	.....	192	.....	Dates taken out and re-engraved for 1882.
Total ...	596	57,695	665½ H. 25 S. H.	

Indian Atlas Sheets (new) completed and published.

	Sq. in.	Letters cut.	Sq. in.	
Atlas sheets—				
31 N.W.	.....	340	7 S. H.	Completed up to margin.
32 S.W.	.....	252	17½ S. H.	
53 N.W.	.....	2,215	55 H.	
66 N.W.	.....	105	131 H.	
67 S.E.	.....	4,974	.....	
77 N.E.	.....	284	21 H.	
129 S.E.	.....	517	3 H.	
130 S.E.	.....	305	17 H.	Ditto up to limits of survey.
138 N.W.	.....	1,594	98 H.	Ditto up to margin.
Total 9 plates ...		10,586	325 H. 17 S. H.	

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30TH SEPTEMBER 1882.

Indian Atlas Sheets (new) in progress.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
	Sq. in.	Letters cut.	Sq. in.	
Atlas sheets—				
8 N.E.	168	17,132	.....	New border cut; plate projected; outline done; writing nearly done as far as drawing.
13 N.E.	29	2,048	.....	Outline and writing completed up to border.
18 N.E.	24	624	.....	Heavy additions of new survey, outline done; writing in progress.
18 S.E.	.....	297	36 S. H.	Completed as far as drawing.
19 N.E.	.....	.....	40 S. H.	Completed as far as survey; plate put down.
19 S.E.	40	578	.....	Reprojected; new border cut; outline and writing in progress.
20 N.E.	40	2,143	.....	Reprojected; new border cut; outline and writing in progress.
20 S.E.	40	3,386	.....	Reprojected; new border cut; writing nearly finished; in progress.
22 N.W.	.....	47	.....	Slight additions; plate again put down.
22 N.E.	72	825	.....	Writing in progress.
22 S.E.	96	.....	.....	Plate put down for fresh drawing.
23 N.E.	40	1,392	.....	Additional outline; lakes shaded and sand banks done; writing in progress.
23 S.E.	30	56	.....	Reprojected; new border cut; outline in progress.
31 S.W.	191	4,756	62 S. H.	Outline and writing finished; sand-hills in progress.
31 S.E.	.....	1,603	.....	Writing almost done; in progress.
32 N.W.	225	3,777	.....	Projected; new border cut; outline finished up to margin; writing in progress.
35 N.W.	.....	.....	84 H.	Slight correction to outline and writing, done.
35 S.W.	.....	.....	.....	Slight correction to outline, done.
36 N.W.	.....	647	.....	Reprojected; new border cut.
36 N.E.	46	4,040	37 H.	Completed as far as drawing; plate put down.
37 S.W.	56	400	.....	Writing in progress.
37 S.E.	104	3,930	.....	Plate in hand.
38 N.E.	.....	919	.....	New border cut; writing in progress.
38 S.E.	.....	3,511	.....	New border, scale cut; and writing finished as far as drawing
40 N.E.	48	335	.....	New border, scale and outside figures cut; outline in progress.
48 N.E.	79	1,629	.....	New border cut and outline repaired; writing in progress.
48 S.E.	81	14,330	.....	New outline cut; writing in progress.
49 N.E.	114	.....	.....	Outline very intricate; in progress.
57 N.W.	.....	.....	.....	New border cut; outline just commenced.
66 S.W.	.....	.....	145 H.	Hills almost finished; in progress.
67 N.W.	2	11,737	4½ H. 1. S. H.	Finished as far as drawing; plate put down.
67 N.E.	12	13,552	.....	Outline and writing, done as far as drawing; hills just commenced.
67 S.W.	68	7,326	.....	Outline and writing, done as far as survey; plate put down.
69 N.E.	97	4,171	.....	New scale cut; writing in progress.
69 S.E.	185	12,708	.....	Outline and writing, done as far as drawing; plate in hand for corrections.
71 S.E.	.....	.....	21 H.	Hills in progress; nearly finished.
76 N.E.	231	502	.....	New border and scale, cut; outline done; writing in progress.
76 S.W.	231	.....	.....	New border cut; outline done; writing just commenced.
76 S.E.	178	7,202	.....	New border cut; outline completed; writing in progress.
77 S.E.	172	4,250	.....	Outline completed; writing just commenced.
78 N.E.	198	950	.....	New border cut; under examination for outline.
138 S.W.	.....	1,011	35 H.	Outside district names, and note, cut; hills in progress.
Total ...	2,896	127,816	326½ H. 139 S.H.	

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

Additions and Corrections to Indian Atlas Sheets.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
Atlas sheets—	Sq. in.	Letters cut.	Sq. in.	
1 N.E.	.....	54	.....	Slight additions, finished.
1 S.E.	.....	94	.....	Ditto ditto.
2 N.E.	10	.....	.....	Alterations to outline done.
3 N.E.	.....	.....	.....	Slight corrections to outline and writing.
8 S.E.	9	349	100 S. H.	Heavy additions; plate completed up to margin.
12 N.E.	.....	20	2 H.	Slight additions completed.
32 N.E.	.....	381	.....	Corrections to outline and writing completed.
35 S.E.	57	4,592	.....	New outline and heavy additions in progress.
36 S.E.	.....	.....	.....	Slight corrections to writing done.
37 N.E.	.....	194	.....	Additional roads; district names and boundaries altered; completed.
45 N.W.	.....	351	.....	Slight additions completed.
45 N.E.	.....	277	.....	Ditto ditto.
45 S.W.	.....	377	.....	Ditto ditto.
52 S.W.	.....	200	1 H.	Slight correction to boundary and hills completed.
53 N.E.	.....	76	.....	Slight additions to writing done.
53 S.W.	.....	166	.....	Ditto ditto.
63A. N.W.	.....	27	.....	Ditto ditto.
64 N.W.	.....	550	.....	Additions to outline and writing done.
64 S.W.	.....	162	.....	Slight additions to outline and writing done.
66 S.E.	.....	.....	1 H.	Slight corrections done.
69 N.W.	.....	1,162	.....	Additions to writing done.
86 S.W.	.....	.....	.....	Slight corrections, done.
86 S.E.	.....	90	.....	Ditto ditto.
87 S.W.	.....	419	.....	Corrections to outline and writing done.
124 S.W.	.....	206	.....	Additional writing and slight corrections to outline and hills done.
124 S.E.	.....	436	.....	Additional writing done.
125 N.W.	.....	84	.....	Ditto ditto.
125 N.E.	.....	244	.....	Ditto ditto.
126 N.E.	.....	.....	16 H.	New hill work done; adjoining hills touched up.
126 S.E.	.....	371	2 H.	Additional writing; boundaries and hills corrected.
127 N.E.	.....	323	3 H.	Additional writing; outline and hills corrected.
127 S.E.	.....	395	4 H.	Additional writing; outline and hills corrected.
128 N.E.	.....	231	.....	Additional writing; boundaries corrected.
129 N.W.	.....	.....	24 H.	Additional hills completed.
129 N.E.	66	1,015	.....	Additional outline and writing done.
130 N.E.	.....	.....	6 H.	Hills re-etched, slight.
130 S.W.	.....	72	.....	Slight additions done.
131 N.W.	.....	88	.....	Slight additions to writing and boundaries, done.
2 S.E., 8 S.W., 9 N.W., 18 N.W., 22 S.W., 23 N.W., 33 S.E., 72 N.E., 72 S.W., 72 S.E., 91 S.W., 34 N.W., 34 N.E., 34 S.W., 34 S.E., and 35 N.E.	12	4,639	.....	Corrections and additions to railways and names done.
Total ...	154	17,645	61 H. 100 S.H.	

Repairs and Additions to Old Plates of the Indian Atlas.

14	.....	326	.....	Additional names done; plate put down.
15	.....	215	.....	Additional names done; plate put down.
16	.....	.....	.....	Outside figures corrected.
17	.....	50	.....	Railway and names cut.
28	.....	260	.....	Additional names and boundaries done.

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30th SEPTEMBER 1882.

Repairs and Additions to Old Plates of the Indian Atlas—concluded.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
Atlas sheets—	Sq. in.	Letters cut.	Sq. in.	
29	.....	239	.....	Corrections and additions to railways done.
30	.....	.....	.....	Slight corrections done.
38	39	60	.....	Additional outline and writing done.
39	.....	300	.....	Additional outline and writing done.
46	.....	394	50 H.	Additional outline and writing done; hills, part repaired; plate put down for more urgent work.
54	48	2,755	.....	Heavy additions; writing in progress.
55	43	1,580	.....	Heavy additions; outline cut; border repaired; writing in progress.
65	.....	21	32 H.	Additional hills etched and portion of old hill work repaired; finished.
68	16	64	.....	Additional outline and writing done.
102	.....	136	.....	Embankments and canals cut; completed.
108	.....	.....	15 H.	Heavy additions; hills just commenced; in progress.
111	.....	.....	.....	Slight additions; border repaired.
112	.....	99	.....	Embankments and boundaries cut; completed.
115	.....	62	.....	Slight corrections to outline and writing done.
116	.....	.....	.....	Slight additions done.
118	.....	52	49 H.	New hill work done; small portion of old hills repaired; completed.
119	.....	276	.....	Slight additions to outline and writing done.
121	.....	216	.....	Slight additions to writing, done.
Total ...	146	7,185	146 H.	

New Plates projected and Borders cut.

12 S.W.	.....	.....	Reprojected; new border cut.
13 N.W.	.....	330	Ditto ditto ditto.
13 S.W. and S.E. ...	.....	.....	Ditto ditto ditto.
14 Four quarters ...	.....	208	Projected; new borders and scales cut.
37 N.W.	.....	.....	Projected; new border cut.
39 N.W.	.....	340	Ditto ditto ditto; scale and outside figures cut.
39 N.E.	.....	.....	New border cut.
40 N.W., S.W. and S.E.	.....	...	Ditto ditto.
60 Four quarters ...	.....	208	Projected and new borders cut.
59 Ditto	.....	430	New borders and scales cut.
62 Ditto	.....	.....	Ditto ditto ditto.
75 N.W.	.....	.....	New scale cut.
80 Four quarters ...	.....	208	Projected; new borders and scales cut.
94 N.W.	.....	52	Projected.
94 N.E. and S.W. ...	.....	104	Projected and new borders cut.
94 S.E.	.....	52	Outside figures cut.
135 N.W. and N.E. ...	.....	.....	Reprojected.
144 Four quarters ...	.....	1,846	New borders, scales, and outside figures cut.
145 Ditto	.....	.....	New borders and scales cut.
153 N.E.	.....	371	Outside figures cut.
153 S.W.	.....	.....	New scale cut.
Total ...	.....	4,649	.....

PROGRESS REPORT OF THE ENGRAVING BRANCH FROM 1st OCTOBER 1881 TO 30TH SEPTEMBER 1882.

Abstract of Work Completed and in Progress.

Engraving.

	Plates.
Atlas sheets completed	9
Ditto in progress in various stages	42
General maps, plans, &c.	46
Repairs, corrections, and additions.	77
Projections and engraved borders cut, &c.	47
Total ...	221

Copperplate-printing.

Impressions taken	7,573
Proofs pulled	1,053
Transfers pulled	341
Total ...	8,967

Steel-facing.

	Plates.
Double elephant plates, steel-faced	14
Ditto ditto re-steeled...	12
Quarter plates steel-faced ...	25
Ditto re-steeled ...	35
Miscellaneous plates steel-faced ...	11
Ditto re-steeled ...	2
Total ...	99

Square inches of hill-etching ...	2,069
Ditto of jungle etched ...	362
Ditto of outlines ...	3,792
Number of letters engraved ...	225,676

C. W. COARD,

Superintendent, Engraving Branch.

JOHN O. N. JAMES,

Assistant Surveyor-General, in charge Engraving Branch.

Table A.

Tabulated Statement of the principal records prepared in the several Executive Offices of the Revenue Branch for the year ending 30th September 1882.

Province and District.	Survey party.	Mapping.						Traverses.		Field Books.		Area Books.		For Settlement Department.		
		Original field sections.	Cadastral 16-inch sheets.	Sheets 4 inch = 1 mile.	Quarter sheets 2 inch = 1 mile 15′ × 7½′.	Index maps.	Triangulation charts.	Main circuit with azimuth computation.	Village or sub-circuit.	Main circuit.	Village or sub-circuit.	Villages.	Fields.	Sheets or traces.	Village areas or khasras.	
N.-W. Provinces.							Cadastral Surveys.									
Ghazipur	No. 4	486	486	.....	.....	.....	.....	.....	1	.....	5	644	209,611	.....	.....	
Ballia	Ditto	815 22 on 32″	815 22 on 32″	.....	6	1	.....	1	3 1 of Benares	1	11 1 of Benares	1,177	678,546	.....	.....	
Mirzapur	No. 5	935	935	.....	26	.....	2	9	11	10	30	.....	.....	.....	525 villages.	
Tarai	Ditto	22	22	.....	.....	.....	.....	.....	3	.....	3	.....	.....	.....	19 do.	
British Burma.																
Hanthawaddy	No. 2	860	860	.....	14	2	.....	2	12	4	22	418	209,763	.....	.....	
Tharrawaddy	No. 7	36 of forest	609	6 of forest	13	1	.....	3	3	3	5	.....	.....	670 traces 1 on 4″ (forest).	220 villages.	
Bassein	No. 8	.....	1,631	.....	22	.....	.....	.....	.....	.....	.....	519	319,709	.....	.....	
Punjab.							Village and Topographical Surveys.									
Rawalpindi	No. 1	35 of Murree Sanitarium on 40″. 53 of Kala Chitta on 4″.	.....	14 of Kala Chitta.	.....	1 of Murree Sanitarium.	2 of Kala Chitta. 3	.....	1 Murree Sanitarium. 2	.....	4 Murree Triangulation. 1 Murree Sanitarium. 2	.....	55	.....	.....	1 alphabetical index supplied to Settlement Officer.
Dera Ismail Khan ...	Ditto	..... *	.....	49	.....	1	.....	2	2	2	2	31 areas of all Dehra Ismail Khan and Bannu.		.....	.....	* The field sheets have been submitted as final sheets recorded in fourth column.
Muzaffargarh	Ditto	..... *	.....	69	.....	1	.....	1	1	1	1	20	42	.....	.....	
N.-W. Provinces.																
Meerut, Bulandshahr, Jumna, and Ganges River Survey.	No. 3	22 Meerut 60 Bulandshahr.	.....	13 of Jumna river. 14 of Ganges river.	21 fine 21 examined.	3 reduction for Atlas of India.	.....	1 of Aligarh	1 of Bulandshahr. 2 of Aligarh 1 Jumna river. 1 Ganges river.	1 of Aligarh	1 of Bulandshahr. 3 of Aligarh 2 Jumna river. 1 Ganges river.	.....	.....	.....	.....	5 traces of Patri forest for Superintendent, Forest Surveys. 1 trace of Ganges river for Collector. 1 trace of Jumna river for Commissioner of Umballa.
Bombay.																
Thana	No. 10	48	.....	24	3	2	3	1	.....	1	2	.....	.....	.....	.....	
Sholapur, Satara, Kolhapur, Nizam's dominions.	No. 11	37 on 2″ scale	.....	.....	25	3 of traverse		3	.....	.....	3	.....	.....	.....	.....	
Bengal.																
Hooghly River Survey ...	No. 6	78 on 16″ 5 on 6″	57 on 16″	.....	.....	2	.....	1	.....	1	3	.....	.....	.....	.....	The Marine Department have been supplied with plots on 16″ scale from Kashipore to Garden Reach, thence on 6″ scale to Diamond Harbour.
Shahabad	No. 4	6 on 4″	.....	9	.....	2	.....	1	1	.....	2	.....	.....	.....	.....	

Deputy Surveyor-General's Office,
Calcutta, the 1st October 1882.

J. E. SANDEMAN, *Major,*
Deputy Superintendent at Headquarters.

Table B.

Statement of work performed in the Drawing and Compiling Branch of the Deputy Surveyor-General's Office during the year ending 30th September 1882.

Title of Maps.	Scale.	Remarks.
Punjab.	Inch. Mile.	
Districts Bannu, Dera Ismail Khan, and Thal of Muzaffargarh, in 44 standard sheets, 30′ × 15′.	1 = 1	Geographical lines have been inserted on 132 of the 4-inch maps, comprising standard sheets 18, 19, 22, 23, 26, 27, 30, 31, and sent to press for photo. reduction to half scale. The 2-inch blue prints of sheets 19, 23, 30, and 31 have been typed and drawn; the drawing of sheets 36 and 39 has also been completed; and sheets 18, 22, 26, and 27 are well advanced, leaving 9 sheets to be taken up to complete these districts. Number of sheets published up to date, 25.
District Rawalpindi, Kala Chitta Pahar, in 27 sheets, 7′ 30″ × 3′ 45″.	4 = 1	The original maps drawn in the Executive's office and received up to date, viz. 13 out of 27, have been examined and completed for press. Number of sheets published up to date, 13.
Punjab and Kashmir boundary, on district Sialkot along the Chenab river and Tawi Nadi.	4 = 1	Original maps prepared by the Executive were examined, completed, and sent to press for publication for the use of the Punjab Government.
North-Western Provinces.		
Districts Moradabad, Budaon, Tarai (part of), and Rampur state, in 22 standard sheets, 30′ × 15′.	.....	The typing and drawing of the remaining 6 two-inch blue prints completed. During the year 20 sheets have been examined and sent to press for reduction and publication on 1-inch scale. Only sheets 63 and 64 now remain to be sent to press. Only one sheet has yet been published.
District Banda, in 16 standard sheets, 30′ × 15′.	1 = 1	Geographical lines inserted on 82 of the original 4-inch maps, comprising standard sheets 142, 112A, 127, 128, 142, 143, 155, 156, for reduction to half scale. Blue prints awaited. The blue prints of the 8 standard sheets mentioned in last year's return have all been typed, drawn, and examined for press.
Meerut Division, districts Shaharunpur, Muzaffarnagar, and Meerut. Fine set showing village boundaries for reproduction to scale in ¼ sheets, 15′ × 7½′.	2 = 1	The originals of 16 sheets drawn in the Executive's office have been received, viz Nos. 1, 2, 3, 4, 13, 14, 15, 16, 17, 18, 27, 27A, 28, 29, 30, and 31; they have been minutely examined in the head office, corrected, rendered suitable for photography, and sent to press for publication. Number of sheets published up to date, 8.

Table B—*continued.*

Title of Maps.	Scale.	Remarks.
North-Western Provinces—concld.	Inch. Mile.	
Coarse set, without village boundaries, for reduction to half scale, 30′ × 15′.	1 = 1	The 19 sheets received to date, viz. Nos. 1 to 7, 13 to 18, 27A, 27 to 31 (19 in all), have been examined, corrected, and sent to press for publication.
		Number of sheets published up to date, 19.
Reduction for Atlas of India, sheets 48 SE and 49 NE, containing parts of districts Muzaffarnagar and Meerut.	½ = 1	Prepared in Executive's office. Re-examined in head office with 1-inch sheets, corrected, and sent to Surveyor-General's office for engraving.
Oudh (new edition), in 65 sheets standard size, 30′ × 15′.	1 = 1	The original maps, with graticule lines inserted, comprising 18 standard sheets, Nos. 105, 106, 121, 122, 123, 135, 136, 137, 150, 151, 163, 164, 165, 166, 167, 176, 177, and 178, have been sent to press for lithography. Since last report sheets Nos. 139 and 140 have been published.
		Number of sheets printed to date, 6.
Bengal.		
District Midnapore, in 18 sheets 30′ × 15′.	1 = 1	The proof sheet No. 17 has been passed through press, and the publication of the entire district is completed.
Do. do. . .	½ = 1	The map of the district begun last year has been completed and submitted to the Surveyor-General's office for engraving.
District Noakholly, in 12 sheets, 30′ × 15′.	1 = 1	All the sheets were published during the year, excepting sheet No. 12, which is now under correction at press.
District Jalpaiguri, in 13 sheets, 30′ × 15′.	1 = 1	Lithographic proofs returned by the Deputy Commissioner have been completed to show thana boundaries, which, however, still await the final sanction of Government. Press order is deferred pending above sanction.
District Mymensing, in 23 sheets, 30′ × 15′.	1 = 1	Geographical lines have been inserted on the main circuit maps, comprising sheets Nos. 240 and 254, and skeleton standards of these sheets, showing the limits of main circuits, &c., have been projected for the guidance of lithographic branch in preparing the transfer drawings to be put down on stone.
District Pooree, Killa Khorda, in 40 imperial sheets.	4 = 1	Examined, touched up, and adapted for photography, hills added, and sent to press.
District Patna, Patna City . .	10 = 1	The original maps have been examined and revised for a second edition, showing additions and alterations supplied by the Superintendent of Works. Sent to press for publication.
Bankipore Civil Station . .	10 = 1	.....

Table B—*continued.*

Title of Maps.	Scale.	Remarks.
Assam.	Inch. Mile.	
District Darrang, sheets 3, 5, 8, 9.	1 = 1	Sheets examined for a second edition and sent to press.
Burma.		
District Hanthawaddy, sheets 115, 116, 124, 125, in 11 sections, 15′ longitude × 7½′ latitude, containing the Syrian township.	2 = 1	The original sheets drawn in the Executive's office were carefully re-examined in the head office and sent to press for publication on full scale for the use of the local Government.
Bombay.		
Deccan Topographical Survey, including the Konkan, in 123 sheets, 30′ × 15′, to latitude 16°.	1 = 1	Since last report the 2-inch standard sheets 61, 62, 68, 75, 76, 77, 84, 85, 86, have been examined, corrected, completed for publication, and sent to press, making 72 sheets sent to press to date, including survey up to 1880-81.
Ditto ditto ditto.		
Quarter sheets, each 15′ × 7½′. Six sheets complete, and portions of seven sheets published on full scale of survey to meet special demands, as noted.	2 = 1	Sheets 75, 76, 77, 84, 85, 86, have been sent to press for reproduction to full scale for Forest Department; also sheets 30 SE, 31 SE & SW, and 35 NE for Executive Engineer, Poona Division; sheets 14 NW, 18 complete, 22 NW & SW, and 26 NW for Collector of Thana. Sheets 30, 31, 35, 14, 18, 22, and 26, had previously been published, in the usual course, on the 1-inch scale.
Index Maps.		
Districts Dera Ismail Khan, Bannu, Rawalpindi, the Meerut Division, districts Ghazipur, Ballia, Benares, Mirzapur, Hanthawaddy, Bassein, Tharrawaddy, the Deccan, and Konkan	On various scales.	The index maps of the Meerut Division and the Deccan have been re-drawn; the others have been revised and brought up to date for the annual report of 1881-82.
Miscellaneous Traces, &c.		
Boundary between districts Jhang and Dera Ismail Khan.	4 = 1	Traced for Deputy Superintendent of Survey.
Boundary between district Shahpur and districts Bannu and Dera Ismail Khan.	4 & 2 = 1	Do. do. do.
Boundary between Nepal and districts Bhagulpore, Durbhanga, and Mozufferpore.	4 = 1	Do. do. do.
Boundary between Nepal and district Chumparun.	2 = 1	Do. do. do.
53 village plans of districts Shahabad and Ghazipur.	4 = 1	Do. do. do.
Hooghly river and one mile of adjoining country on both banks from Phulouria Semaphore to Sola Mohan Creek.	4 = 1	Do. do. do.
Inserted village boundaries on Hooghly river sheets from Kanchrapara to Calcutta.	4 = 1	Do. do. do.
A line of villages along left bank of Hooghly river from Atcheepore to Brool Semaphore.	4 = 1	Do. do. do.
Plan of jungle block comprising 29 villages of district 24-Pergunnahs.	4 = 1	Do. do. do.

Table B—*continued.*

Title of Maps.	Scale.	Remarks.
Miscellaneous Traces, &c.—continued.	Inch. Mile.	
Plans of two French settlements in district Balasore.	8 = 1	Prepared for Collector.
Completed boundaries of waste land blocks on the Deputy Commissioner's copies of atlas sheets.	4 = 1	For Deputy Commissioner.
Sheets containing Jalpaiguri Station and Environs.	4 = 1	Traced for Mr. Bond, Assistant, Great Trigonometrical Survey.
Boundary common to Sind and Khelat.	4 = 1	Traced for Agent, Governor-General, Khelat.
13 old mehalwar maps of district Sylhet, in duplicate.	16 = 1	Traced to illustrate report on Sylhet Test Survey.
Several Deccan triangulation charts.	½ = 1	Traced for Deputy Superintendent.
Ditto ditto ditto .	1 = 4	Do. do. do.
Inserted course of Megna river as surveyed by Deputy Collectors under orders of the Board of Revenue, Lower Provinces, on the survey atlas sheets in this office.	4 = 1	For office record.
Prepared a plot of portion of Sarua river.	32 = 1	For Settlement Officer, Khorda.
Extract from plan of mouzah Jujhursing.	32 = 1	Do. do. do.
Boundary of 3 villages of district Azamgarh, touching on Ghazipur.	16 = 1	Traced for Deputy Superintendent.
Sheets comprising the Eta Hills, district Sylhet.	4 = 1	Do. do. do.
Several board plans of Hooghly river survey by Colonel Leach.	16 = 1	Traced for comparison with previous surveys.
Prepared a plot of Rathamati river.	8 = 1	For Settlement Officer, Khorda.
Ditto 2 villages, district Jaunpur.	16 = 1	For Settlement Commissioner, Punjab.
40 village plans and grants . .	4 = 1	Copied for Deputy Commissioner and others.
1 sheet Punchunnogram . .	150ft. = 1in	Traced for Deputy Collector.
Typed title pages (24 sheets) . .	.....	For volumes of Burma published cadastral plans.
Inserted 1″ sheet numbers and limits on several copies of Burma map.	.....	For office record and use of executives.
	Inch. Mile.	
Inserted boundary as surveyed by Messrs. Shaw and Smart between Goalpara and Garo Hills on 2 copies.	½ = 1	For Deputy Commissioner and office use.
Completed maps of districts Agra and Muttra to show numbers and limits of 4″ sheets.	¼ = 1	For Executive Engineer.
Completed set of sheets of district Lakhimpur to show the boundary adjoining Seebsagore, as shown in the 4″ sheets of the latter district.	1 = 1	For Deputy Commissioner.
Completed all the printed copies in stock of sheet No. 11, Deccan series, to show the portion of district Thana surveyed in 1879-80.	1 = 1	For office use and issue.
Completed all the printed copies in stock of sheet No. 10, Deccan series, to show boundaries that were not available at time of publication.	1 & 2 = 1	Do. do. do.
Prepared new index to the 1″ sheets of Bengal.	1 = 16	For office use.
Prepared diagrams showing the average heights of 5 minute compartments in the several districts of the Punjab and N.-W. Provinces, as far as available in this office.	.....	For Surveyor-General's Office.

Table B—*continued.*

Title of Maps.	Scale.	Remarks.
Miscellaneous Traces, &c.—concluded.	Inch. Mile.	
Coloured a set of sheets of district Chumparun to show latest thana and subdivision boundaries.	1 = 1	For Surveyor-General's Office.
Coloured a set of sheets of districts Hooghly and Howrah.	1 = 1	Do. do.
Map-colouring.	*No. of Maps.*	
Maps on various scales . . .	109	For Surveyor-General's Office.
Do. do. . . .	109	For Deputy Surveyor-General's office.
Do. do. . . .	610	For the India Office.
Do. do. . . .	1,044	For Government officials.
Total .	1,872	
Examination of Proof Sheets.		
Photozincograph maps . . .	282	
Lithograph maps . . .	34	

Description of Work.	Remarks.
Traverse Data, &c., supplied.	
Of 50 villages of Moradabad along Ganges river.	For Deputy Superintendent.
Of Hooghly villages from Botanic Garden to Chandernagore (60 pages).	,, Assistant ditto.
Of Eta Hills, district Sylhet, with co-ordinates of village trijunctions.	,, Ditto ditto.
Of Cachar grants (17 pages)	,, Deputy Commissioner.
Of Jaunpur, along Benares, with co-ordinates of Pargana trijunctions.	,, Ditto Superintendent.
Of Captain Samuell's Nepal boundary, along Purneah and Bhagalpur.	,, Assistant ditto.
Of districts Tirhoot and Sarun, along Nepal...	,, Ditto ditto.
Of M. C. 11, 12, and 13 of Moradabad, along Ganges river.	,, Deputy ditto.
Of Agra and Muttra, along Aligarh ...	,, Ditto ditto.
Of Sirsa and Rohtak, along Hissar ...	,, Ditto ditto.
Triangulation values of three charts of Deccan Topographical Survey.	,, Ditto ditto.
Alphabetical indexes of district Hanthawaddy (four copies).	,, Settlement Officer.

Table B—*concluded.*

Description of Works.	Remarks.
Computations examined.	
District Jaunpur 1878-80	Final examination.
Ditto Banda 1877-78	
Districts Saharanpur and Muzaffarnagar 1878-79	
Miscellaneous Work.	
Calculation of areas of Hill Tipperah and Gurjat states, also Thana areas of districts Chittagong, Sonthal Pergunnahs, Singbhoom, Hazaribagh, Lohardugga, and Darjeeling.	For Bengal Government.
Preparation of area statement of district Noakhally by summation of villages.	„ publication with sheets.
Calculation of co-ordinates for the projection of districts Banda, Tarai, Dera Ismail Khan, Bannu, and Mymensing, and of Patna City.	„ office use.
Calculation of areas of districts Goalpara and Garo Hills according to revised boundaries.	„ Deputy Commissioner.
Entering of heights of 5′ compartments for the districts of the Punjab, North-Western Provinces, Oudh, Bengal, and Central Provinces.	„ Surveyor-General's Office.
Preparation of a statement showing scale and character of survey of the districts in Central Provinces.	„ Government Central Provinces.

Deputy Surveyor-General's Office, *Calcutta, 1st October* 1882.

F. W. KELLY, *Surveyor.*

J. E. SANDEMAN, *Major, Dy. Supdt. at Headquarters.*

Table C.

State of Publication of Cadastral Maps on the 30th September 1882.

Districts.	Number of Sheets. Maps prepared. Up to 30th September 1881.	Maps prepared. Added during past 12 months.	Maps prepared. Total up to 30th September 1882.	Published. Up to 30th September 1881.	Published. During 1882. By Surveyor-General's Office.	Published. During 1882. Total to 30th September 1882.	Published. During 1882. Remaining to be published.	Remarks.
N.-W. Provinces.								
Agra	2,924	.....	2,924	2,924	.....	2,924	.....	(a) Figures of previous return have been changed to agree with final results. (b) These figures are liable to alteration until publication has been completed.
Azamgarh	930	.....	930	930	.....	930	.....	
Banda	(a)3,317	.....	3,317	2,953	364	3,317	.....	
Bijnour	31	.....	31	31	.....	31	.....	
Ghazipur and Ballia ...	(a)2,695	1,323	(b)4,018	2,034	994	3,028	990	
Hamirpur	2,926	.....	2,926	2,926	.....	2,926	.....	
Jaunpur	(a)3,434	.....	3,434	2,889	545	3,434	.....	
Moradabad and Terai ...	4,023	.....	4,023	4,023	.....	4,023	.....	
Mutira	1,658	.....	1,658	1,658	.....	1,658	.....	
Mirzapur	(a)1,906	955	(b)2,861	1,129	622	1,751	1,110	
Terai	39	22	(b)61	.....	15	15	46	
Total ...	23,883	2,300	26,183	21,497	2,540	24,037	2,146	
British Burma.								
Bassein	1,125	1,031	(b)2,156	119	840	959	1,197	
Hanthawaddy	2,203	860	(b)3,063	843	1,281	2,124	939	
Tharrawaddy	481	660	(b)1,141	.....	309	309	832	
Total ...	3,809	2,551	6,360	962	2,430	3,392	2,968	
Bengal.								
Patna and Gya	3,054	.....	3,054	3,054	.....	3,054	.....	
Shahabad	4,924	.....	4,924	4,924	.....	4,924	.....	
Pooree (Khorda estate)...	3,311	673	(b)3,984	1,010	104	1,114	2,870	
Total ...	11,289	673	11,962	8,988	104	9,092	2,870	
Assam.								
Sylhet	.....	61	(b)61	.....	16	16	45	
Total ...	.....	61	61	.....	16	16	45	
Grand Total, N.-W. Provinces, Burma, Bengal, and Assam	38,981	5,585	44,566	31,447	5,090	36,537	8,029	

Detail of Examination in connection with Publication.

Provinces.	Number of Sheets. Examined and rendered suitable for photozincography.	Traced and examined for zincography.	Proof copies examined previous to press order.	Coloured and subsequently examined.	Remarks.
North-Western Provinces	1,881	710	2,563	2,540	Scale 16 inches to a mile.
British Burma	1,371	706	2,234	2,450	Ditto ditto.
Bengal	286	1	104	104	Scale 32 ditto.
Assam	16	.....	16	16	Scale 16 ditto.
Total ...	3,534	1,417	4,967	5,090	

Deputy Surveyor-General's Office,
Calcutta, 1st October 1882.

J. E. SANDEMAN, *Major*,
Deputy Superintendent at Headquarters.

CADASTRAL SURVEY.—DISTRICT MIRZAPUR.—SEASON 1881-82.

Specimen of Khusrah.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of the fields.	Name of thok or patti.*	Name of proprietor, with name of father, his caste and place of residence.	Name of cultivator, with name of father and caste, and how many years he has been cultivating.	Name of under-cultivator, with name of father and his caste.	TOTAL AREA.		Barren waste.	CULTIVABLE WASTE.		CULTIVATION.		Nature of crop.	REMARKS.
					Acres.	Sikari bighas.		Lately thrown out of cultivation.	Fit for cultivation.	Irrigated.	Non-irrigated.		
					D. D.	D. D.				D. D.	D. D.		
1	Patti Gobardhan.	Gunpat, son of Gonesh; caste Kurmi; place of residence, Daudpur; 4 annas.	Nur Ali, son of Pir Buksh; caste Sheikh; residing in the village; cultivating for 16 years.	.....	2 41	3 14	...	...	...	...	2 41	Til ...	Non-irrigated.
2	Patti Dindayal.	Rambuksh, son of Sita Ram; caste Thakur; residing in the village; 8 annas.	Data Ram, son of Gonesh Misser, caste Brahman; residing in the village; cultivating for 14 years.	Debi, son of Dina; caste Kewat; residing in the village.	1 89	2 18	...	...	...	...	1 89	Do.	
3	Patti Dayaram.	Jafer Ali, son of Baker Ali; caste Syud; place of residence Mohulla Targhat, Mirzapur: 4 annas.	Raghubar Singh; son of Rameshar Singh; caste Thakur; residing in the village; cultivating for 24 years.	.....	2 78	4 7	...	...	...	2 78	...	Wheat	There is a pucca well for irrigation.
4	Patti Gobardhan.	Gunpat, of patti No. 1 ...	Nur Ali, of patti No. 1 ...	Gauri, son of Jamna Dass; caste Bania; residing in the village.	2 63	4 1	...	...	...	2 63	...	Jow ...	Irrigated from well in No. 3.
5	Patti Dayaram.	Jafer Ali, of patti No. 3...	Ramkumar, son of Dayakunar; caste Brahman; residing in the village, cultivating for 10 years.	.....	5 49	8 9	...	...	...	...	5 49	Tisi ...	Five mango-trees belonging to Ramkumar, son of Dayakumar; caste Brahman; residing in the village.

* NOTE.—On the first division of the lands of a village between the several proprietors, the divisions are called patties. When any of the patties are again subdivided between proprietors, the original divisions or patties are called thoks and the subdivisions are called patties; so that the thok is the larger or more important division of a village, and patti is the minor, provided both exist in a village.

CADASTRAL SURVEY.—DISTRICT MIRZAPUR.—SEASON 1881-82.

Specimen of Jummabundi Slips.

1	2	3	4	5	6	7	8	9	10	11	12	13
Name of thok or patti and of zemindar.	Serial number of cultivators.	Name of cultivator, his father's name, his caste and place of residence, and how many years he has been cultivating.	Name of mortgagee, his father's name, his caste and place of residence.	Name of sub-cultivator, his father's name, his caste and place of residence.	Khusrah field numbers.	Area in sikari bighas.	Area of bighas, sikari, on which no rent is paid to zemindar.	AREA ON WHICH RENT IS PAID IN MONEY.		AREA ON WHICH RENT IS PAID IN KIND.		REMARKS.
								Area of bighas, sikari, on which rent is paid to the zemindar in money.	Amount of rent paid in money.	Area in bighas on which rent is paid in kind (standing crop).	Amount taken by zemindar in kind per annum of 40 seers.	
						D. D.		D. D.				
	1	Babu Lal, son of Brij Lal; caste Bund; residing in the village.	Shewshankar, son of Harshankar; caste Gharwar; residing in the village.	Gujadhar Singh, son of Bisheshar Singh; caste Thakur; place of residence, Rampur.	27 32	4 10 9 11	....	4 10 9 11	....	.....	.....	
				Total ...	2	14 1	.....	14 1	.....	.....	.....	
	2	Sukhnandan, son of Bukhtawar; caste Kurmi; residing in the village. Proprietor; ditto; cultivating for 10 years.	Shewsambat, son of Ganpat Singh; caste Bahman; residing in the village.	Raghubar Singh, son of Rachmanar Singh; caste Bahman; place of residence, Chhapri.	5 12 15	10 12 7 15 11 18	3 0	7 12 7 15 11 18	....	.....	.....	
				Total ...	3	30 0	3 0	27 9	.....	.....	.....	

Extract from Report of J. O. N. JAMES, Esq., *Assistant Surveyor-General, in charge Lithographic Branch, Surveyor-General's Office.—Season* 1881-82.

THE number of maps, plans, drawings, &c., printed during the year amounts to 157,440 copies. Of these 121,353, or more than ¾ths, were for other departments. During the same period 10 sheets of the Oudh Revenue Survey of the year 1860 to 1871, and 2 sheets of the Julpaiguri district, each comprising 30′ of longitude by 15′ of latitude, and an Index map to the sheets of the Noakholly district, besides 337 subjects of all sorts and sizes (chiefly small) for other departments, were newly drawn either on stone direct, or on paper and transferred to stone.

The first edition of the map of India in 6 sheets, scale 1 inch = 32 miles, transferred to stone in 1881, was completed and printed in December of the same year; a second issue, in which many additions and corrections were made on the stones, was also published during the year under review (1881-82).

The outline of the new map of Bengal, scale 1 inch = 16 miles, was obtained from transfers from the engraved plates, in 4 sections; the hills were drawn direct on stone with corrections and additions. The frequent changes in the district boundaries in Bengal have necessitated the lithography of this map in two sets of stones,—one to shew in black the topographical and other permanent details, and the other to shew in red the varying district boundaries and names. This map is now nearly ready for publication.

The outline and part of the engraved hill work of a preliminary map of the Central Provinces, scale 1 inch = 16 miles, was transferred to stone from the incomplete engraved plates, and the incomplete portions of the hills were drawn on stone, and the map was nearly in a fit state for publication by the end of September 1882.

Eleven sheets of the 1-inch maps of the Noakholly district, drawn during the preceding year, have been printed and published during the year; also two sheets of the new edition of Oudh, Nos. 139 and 140.

The total number of subjects printed in the lithographic printing room was 393, of which 26 were printed in two colours, 28 in three colours, 6 in four colours, 2 in five colours, and 1 in six colours, and the remainder in black only. These required 182,091 pulls or impressions.

Four engraved sheets of the Indian Atlas (Nos. 30, 67, 112, and 119) were in a damaged condition and past repair. Transfers to stone were made from these plates, and many additions and corrections were then made on the stone to furnish a stock of the sheets for issue pending the preparation of new copperplates. The following district maps were published from material obtained by transfers from the engraved Atlas plates, with additions and alterations on stone, viz. Seebsaugar, Dacca, Sylhet, Beerbhoom, Balaghat, Kamroop, and Sonthal Pergunnahs. Maps of the following districts, obtained in a similar manner, will be published shortly, viz. Goalpara, Kulnah, and Durrang.

The statement L. 1 shews the detail of the departmental work completed during the year, amounting in value to Rs. 25,830. Statement L. 2 shews the amount and value of work done for other departments, amounting to Rs. 20,111. Statement L. 3 shews the amount and value of work done in the type department, amounting to Rs. 8,317, exclusive of the value of transfers included in the cost of the several lithographic maps. Statement L. 4 is the abstract of the whole work completed during the year, as well as the outlay in salaries and contingent charges.

Mr. Lepage, who had been officiating as Head Assistant, was permanently appointed to the post in December 1881. He obtained leave for three months, and during his absence Mr. A. G. Palmer, Engraver, officiated and conducted the duties of head assistant very satisfactorily.

Mr. Niven, Head Printer, obtained leave on medical certificate for one year, from 11th April 1882, and during his absence Mr. Watson, of the Photographic Branch, has officiated as Printer. Mr. Ferns, Draftsman, was transferred to the Guzerat Survey Party on the 1st December 1881.

Messrs. Lepage and Watson have performed their duties zealously, and have done their utmost to keep pace with the heavy demands made on the office from numerous Government departments. The draftsmen and clerks have given satisfaction.

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC BRANCH, SURVEYOR-GENERAL'S OFFICE, BETWEEN THE 1st OCTOBER 1881 AND 30TH SEPTEMBER 1882.

L. 1.

Work done for the Survey Department.

DESCRIPTION OF MAPS.	Scale of maps.	Size of each sheet.	Number of sheets.	Number of coloured copies.	Number of uncoloured copies.	Total number of copies printed.	Number of impressions.	Value.	REMARKS.
								Rs. A. P.	
New maps, &c., drawn during the year.									
INDEX MAP.									
Index to the sheets of district Noakholly.	Drawn on transfer paper.	.....	Half-sheet, super royal.	1	...	302	302	302	99 12 2	
REVENUE SURVEY MAPS.									
Map of Oudh Revenue Survey, sheets Nos. 103, 104, 122, 123, 138, 152, 165, 166, 167, and 178, 2nd edition.	Drawn on transfer paper.	1 inch = 1 mile	Double royal ..	10	...	.....	.....	.....	5,673 7 8	Not yet printed.
Map of district Jalpaiguri in 18 sheets, sheets Nos. 1 and 2.	Re-drawn on transfer paper.	1 inch = 1 mile	Ditto ...	2	...	.....	.....	.....	429 3 2	Ditto.
General maps transferred from engraved plates.									
Outline map of Bengal, Behar, Orissa and Chota Nagpore, in 2 sheets.	Ditto ditto	1 inch = 16 miles.	Ditto ...	2	...	100	100	100	321 10 8	
Map of Central Provinces, in 2 sections.	Slight corrections made and portions of hills drawn on stone.	1 inch = 16 miles.	Double elephant.	2	...	.....	.....	.....	145 9 3	Ditto.
Outline Map of India, in 3 sheets	Additions and corrections made.	1 inch = 64 miles	Ditto ...	2	...	.....	.....	.....	443 9 4	Ditto.
Map of the Provinces of Bengal, Behar, Chota Nagpore and Orissa, in 4 sections.	Corrections and additions made and hills drawn on stone.	1 inch = 16 miles.	Atlas ...	4	...	.....	.....	.....	1,023 7 3	Ditto.
DISTRICT MAPS.									
Map of district Seebsaugor ...	Corrections and additions made.	1 inch = 4 miles	Double royal...	1	...	251	251	251	215 5 7	
Do. of ditto Goalpara ...	Ditto ditto	1 inch = 4 miles	Antiquarian ...	1	...	.....	.....	.....	90 7 9	Ditto.
Do. of ditto Kulnah	Ditto ditto	1 inch = 4 miles	Atlas ...	2	...	.....	.....	.....	70 13 6	Ditto.
Maps, &c., drawn previously, but printed during the present year.									
DISTRICT MAP.									
Map of district Hoshiarpore, in 4 sheets.	Corrections and additions made and hills drawn on transfer paper.	1 inch = 2 miles	Ditto ...	4	...	104	104	416	576 3 11	
REVENUE SURVEY MAPS.									
Map of district Noakholly, in 12 sheets, sheets Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11.	Corrections made	1 inch = 1 mile	Double royal...	11	...	3,102	3,102	3,102	1,706 10 9	
Map of Oudh, Revenue Survey, sheets Nos. 139 and 140, 2nd edition.	Ditto ditto	1 inch = 1 mile	Ditto ...	2	...	564	564	564	404 12 0	
Maps transferred previously from the engraved sheets, but printed during the present year.									
ATLAS SHEETS BY TRANSFERS FROM PLATES.									
Map of Indian Atlas, full sheet, No. 40.	Further additions and corrections made and colour stones prepared.	1 inch = 4 miles	Antiquarian ...	1	152	50	202	304	283 15 5	
Ditto ditto, ditto, No. 48	Further additions and corrections made.	1 inch = 4 miles	Ditto ...	1	...	152	152	152	267 10 8	
Map of India, in 6 sheets, 1st issue	Ditto ditto	2 inch = 32 miles	Double elephant.	6	...	3,897	3,897	3,897	3,401 14 6	
Ditto ditto, ditto, 2nd issue	Additions and corrections, &c., made and transfers taken.	1 inch = 32 miles	Ditto ...	6	...	1,932	1,932	1,932	2,427 5 4	
Map of Indian Atlas, full sheets, Nos. 30 and 119.	Corrections and additions made and colour stones prepared.	1 inch = 4 miles	Antiquarian ...	2	200	200	400	800	557 6 3	
Ditto ditto ditto, No. 67 ...	Corrections and additions made.	1 inch = 4 miles	Ditto ...	1	...	.....	.....	.....	63 9 3	Ditto.
Ditto ditto ditto, No. 112 ...	Ditto ditto	1 inch = 4 miles	Ditto ...	1	...	152	152	152	261 12 6	
DISTRICT MAPS.									
Map of district Dacca	Further corrections made and colour stone prepared.	1 inch = 4 miles	Atlas ...	1	100	100	200	300	113 10 8	
Carried over ...	.....	.....	.....	62	552	10,006	11,158	12,274	18,667 7	

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC BRANCH, SURVEYOR-GENERAL'S OFFICE, BETWEEN THE 1st OCTOBER 1881 AND 30th SEPTEMBER 1882.

Work done for the Survey Department—continued.

Description of Maps.		Scale of maps.	Size of each sheet.	No. of maps.	Number of coloured copies.	Number of uncoloured copies.	Total number of copies printed.	Number of impressions.	Value.	Remarks.
									Rs. a. p.	
Brought forward ...	.....	.....	.....	62	532	10,606	11,138	12,274	18,467 5 7	
District Maps—continued.										
Map of district Sylhet	Further corrections, &c., made.	1 inch=4 miles	Atlas ...	1	...	336	336	336	267 5 11	
Do. of ditto Beerbhoom ...	Further corrections made and colour stone prepared.	1 inch=4 miles	Super royal ...	1	304	100	204	308	96 15 4	
Do. of ditto Balaghat ...	Further corrections, &c., made.	1 inch=4 miles	Atlas ...	1	...	250	250	250	333 15 5	
Do. of ditto Southal Pergunnahs	Further corrections, &c., made and colour stone prepared.	1 inch=4 miles	Double royal...	1	102	102	204	306	249 5 8	
Do. of ditto Kamaoon ...	Corrections and additions made.	1 inch=4 miles	Atlas ...	1	...	252	252	252	101 3 2	
Do. of ditto Raepore	Ditto ditto	8 inch=4 miles	Antiquarian ...	2	...	.....	.....	.....	63 1 0	Not yet printed.
Reprints.										
General Maps.										
Map of Southern Afghanistan, in 4 sheets.	.....	1 inch=4 miles	Ditto ...	4	...	400	400	800	267 0 0	
Map of Punjab Provinces, in 8 sheets, sheets Nos. 1, 4, 6, and 7.	.....	1 inch=8 miles	Double elephant.	4	...	170	170	340	97 1 8	
Map of India, No. 2, 5th edition ..	.....	1 inch=128 miles	Imperial ...	1	100	25	125	225	66 0 0	
Ditto in 2 sheets	.....	1 inch=64 miles	Double elephant.	2	...	25	25	50	25 5 10	
Map of British Burma, Pegu division, sheets Nos. 3 and 4.	Corrections and additions made.	4 inch=4 miles	Antiquarian	2	...	240	240	240	217 3 4	
Map of Eastern Bengal, Assam, Burma, and part of China and Siam, in 4 sheets.	.....	1 inch=32 miles	Imperial ...	4	...	50	50	400	66 0 6	
Map of North-Western Provinces and Oudh, in 4 sections.	.....	4 inch=16 miles	Ditto ...	4	...	50	50	400	106 2 8	
Map of Eastern and Western Bengal, sheets Nos. 8, 11, 13, 19, and 20.	.....	1 inch=8 miles	Ditto ...	5	100	115	215	315	92 4 5	
Map of Eastern Bengal, sheet No. 10.	Corrections made and colour stones prepared.	1 inch=8 miles	Ditto ...	1	100	50	150	250	92 11 7	
Map of Assam, in 2 sheets, sheets Nos. 3, 5, 7, and 8.	Corrections made and colour stones prepared of No. 3 only.	1 inch=8 miles	Ditto ...	3	275	100	375	975	215 14 0	
Map of Bengal, Behar, and Orissa	.....	1 inch=32 miles	Double elephant.	1	...	75	75	75	42 3 8	
District Map.										
Map of district Mymensingh ...	.....	1 inch=4 miles	40 × 40 paper	1	...	100	100	100	51 15 4	
Index Maps.										
Index Maps, Nos. 1, 2, 5, 7, 8, and 9 parties, to accompany annual report.	Corrections, &c., made and colour stones prepared.	...	Foolscap ...	5	2,500	250	2,750	7,700	972 2 10	
Index to the Survey of South Sylhet and Tipperah hills, to accompany annual report.	Corrections made and colour stones prepared.	.....	Ditto ...	1	500	65	565	1,565	201 9 6	
Index to the sheets of Baluchistan Survey, to accompany annual report.	Ditto ditto	.....	Ditto ...	1	450	50	500	950	183 10 0	
Index to the Indian Atlas showing the state of the engraving to 1st October 1881, to accompany annual report.	Ditto ditto	.....	Ditto ...	1	600	.....	600	1,200	85 1 7	
Map of India, showing the progress of the Imperial Survey to 1st October 1881, to accompany annual report.	Ditto ditto	1 inch=128 miles	Imperial ...	1	400	.....	400	1,600	192 3 10	
Index to the topographical survey, district Kohat	.....	.....	Half-sheet foolscap.	1	...	105	105	105	9 7 8	
Small index to the sheets of Indian Atlas.	Colour stone prepared.	.....	Foolscap ...	1	500	25	525	1,025	84 4 11	
Plans.										
Plan of Calcutta, in 2 sheets ...	.....	6 inches=1 mile	Double elephant.	2	...	407	407	429	132 14 6	
Guide plan of Simla and Jutog ...	.....	4 inches=1 mile	Atlas ...	1	...	109	108	103	54 3 6	
Total ...	.....	.....		115	6,233	13,776	20,009	32,722	22,476 13 5	
Miscellaneous maps, &c.	.....	.....		18	...	.....	9,578	1,038	846 14 11	
Cadastral maps	.....	.....	Items ...	22	...	.....	234	234	211 15 2	
Departmental forms	.....	.....		27	...	.....	14,216	17,877	2,794 13 6	
Grand Total ...	.....	.....	.....	181	6,233	43,776	36,037	52,776	25,330 9 0	

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC BRANCH, SURVEYOR-GENERAL'S OFFICE, BETWEEN THE 1st OCTOBER 1881 AND 30th SEPTEMBER 1882.

L. 2.

Work done for other Departments.

Names of Departments.	Number of maps.	Number of sheets.	Number of sheets coloured.	Number of sheets uncoloured.	Number of copies.	Number of impressions.	Value.
							Rs. A. P.
Foreign Department	28	29	... ..	29	1,711	1,731	941 10 2
Military Department	44	52	1	51	10,663	12,016	2,477 14 10
Home, Revenue, and Agricultural Department	4	4	3	1	3,263	5,738	518 3 2
Telegraph Department	6	6	.....	6	4,633	5,531	594 11 1
Bengal Office	34	34	11	23	31,069	33,094	2,128 2 4
Marine Survey Department	1	1	1	... ..	240	720	221 8 3
Sanitary Commissioner	1	1	1	.....	1,075	3,205	481 12 8
North-Western Provinces *Gazetteer*	4	4	.....	4	2,319	2,319	515 11 1
Public Works Department, Government of India and Bengal.	9	9	1	8	2,137	2,239	946 0 5
Punjab Government	3	3	1	2	1,542	2,832	478 11 5
Quarter-Master-General	4	4	....	4	1,105	1,955	59 15 10
Office of the Superintendent, Census Operations, in Bengal	5	5	4	1	5,052	10,377	1,326 9 10
Meteorological Reporter to the Government of India ...	7	7	3	4	2,639	4,239	514 3 0
Archæological Survey of India	24	24	.....	24	13,560	3,955	1,029 9 0
Geological Survey of India	10	10	4	6	5,768	12,873	1,688 12 11
Miscellaneous drawings	83	83	8	75	30,677	26,571	3,969 10 10
Maps, &c., drawn but not printed	70	70	4	66	.....	.....	2,317 13 3
Total ...	337	346	42	304	1,21,353	1,29,295	20,111 0 10

L. 3.

Statement of type-work executed, exclusive of transfers, &c., already included in the cost of the several Lithographic Maps, &c.

Subject.	Items.	No. of copies.	No. of impressions.	Value.
				Rs. A. P.
Circular Orders	8	1,025	1,225	55 5 0
Memorandum, &c.	413	2,00,207	2,73,279	5,065 9 0
Forms, &c., for Survey Department	42	39,201	1,17,036	1,867 0 0
Transfers of headings, footnotes, references to published maps for Photographic Branch	925	8,502	8,502	1,329 8 0
Total ...	1,388	2,49,085	4,00,102	8,317 6 0

L. 4.

General Abstract of Out-turn and Value of Work performed.

Description of Maps.	No. of sheets.	No. of copies.	No. of impressions.	Value.
Departmental Work.				Rs. A. P.
General and district maps, &c, ...	63	10,431	14,078	10,964 14 0
Index maps	12	5,747	14,447	1,150 2 6
Revenue Survey sheet maps, scale 1"=1 mile	13	3,666	3,666	2,171 6 9
Plans	8	215	536	187 2 0
Miscellaneous maps, &c.	18	1,578	1,938	816 14 11
Cadastral maps	21	234	234	211 15 2
Departmental forms ... ... Items	27	14,416	17,577	2,294 13 6
Maps, &c., drawn but not printed	24	.....	.....	8,003 4 2
Total ...	181	36,087	52,776	25,830 9 0
Work done for other departments	346	1,21,353	1,29,295	20,111 0 10
Total of drawing and printing in Lithographic Department	527	1,57,440	1,82,071	45,941 9 10
Work done in Type Department ... ... Items	1,388	2,49,085	4,00,102	8,317 6 0
Total value ...	.....	.....	.....	54,258 15 10

Statement of Expenditure.

	Rs. A. P.
Establishment	29,919 6 9
Contingent charges	4,659 10 10
Total ...	34,579 1 7

Surveyor-General's Office,
Lithographic Branch,
Calcutta, 22nd December 1882.

JOHN O. N. JAMES,
Asst. Surveyor-General,
in charge, Lithographic Branch,
Surveyor-General's Office.

Extract from Report of MAJOR J. WATERHOUSE, *Assistant Surveyor-General, in charge Photographic Branch, Surveyor-General's Office.—Season* 1881-82.

I HAVE the honour to submit the usual tabular statements of work done, expenditure, &c., in this branch of your office during the survey year from 1st October 1881 to 30th September 1882, viz.—

(*A*) Abstract of work performed during 1881-82. (Printed in Part II.)
(*B*) Comparative statement of the out-turn of 1880-81 and 1881-82.
(*C*) Statement showing the value of work done for other departments.
(*D*) Statement of expenditure and value of work done.

OUT-TURN.—*Ordinary.*—The out-turn of ordinary departmental and extra-departmental work shows a considerable increase in negatives, transfers, and press pulls, though the number of printed sheets, both single and combined, is less.

The work passing through the office during the year has been of the usual miscellaneous character, as will be seen from the return of work done for other departments, which shows a steady increase in this direction. The Egyptian campaign caused a great demand for reproductions of charts of the Suez Canal, Red Sea, ports of Alexandria, Port Said, and Suez; also for maps of Egypt. The total number of these maps printed was about 4,430.

Cadastral.—On the cadastral side also there has been a considerable increase in the number of sheets photographed and transferred to zinc, the total number amounting to about 5,000 sheets, which is the highest figure yet reached. The out-turn in pulls and printed sheets is not so great, owing chiefly to the reduction in the number of copies printed off for the North-Western Provinces from 25 to 10, which entails loss of time in constantly changing plates.

Arrangements have now been made for a steady out-turn of 20 to 22 sheets a day, or about 6,000 sheets in the year, part being done by photography and part by tracings prepared for zincography in the Deputy Surveyor-General's office; and this is about the full extent to which we can work with the present staff and accommodation. The number of sheets a year that can be turned out depends, however, upon the number of copies printed of each sheet; and as this varies for each province—thus for North-Western Provinces 10, for Burmah 34, for Bengal (Khurda) 43—it is difficult to make any close estimate of probable out-turn.

EXPENDITURE.—As will be seen from Table D, the expenditure of the office, including establishment and stores, has been Rs. 93,146, as against Rs. 89,560 of the previous year. The value of work done for which credit is taken, as calculated by the scale drawn up by me in 1879, has been Rs. 1,14,795, showing a balance in favour of the department for the year of Rs. 21,648. The value of the whole work done during the year is Rs. 1,25,260. From this it appears that the rates laid down in the scale are more than amply sufficient to cover the cost of the work done, and I propose to take an early opportunity of going into this question again, to see whether the rates can be reduced.

PERSONNEL.—I returned from furlough and relieved Major Cowan on the 26th December 1881. There have been few changes in the establishment during the year, the principal one being Mr. Caddy's resignation in February of his post of storekeeper. Mr. Dempster has since had charge of the stores and making up collodion, &c. Mr. J. Harrold returned from furlough and resumed charge of the photo-transfer printing branch on the 21st June. In the zinc-printing branch Mr. E. A. LeFranc has been superintending the cadastral work during Mr. Watson's deputation to lithographic branch since 10th April; and during Mr. B. Mackenzie's absence on privilege leave from July to October he took charge of the office presses, Mr. A. P. DaCosta taking charge temporarily of the cadastral presses.

The establishment of the office was generally reorganised and arranged from the commencement of the current financial year, as reported to Government in your No. 1146, dated 19th April 1882. The changes, however, were chiefly in designation and pay of the different posts. I have not yet been able to fill the post of head assistant, but hope to find a suitable incumbent in the course of the current year.

PROCESSES.—There have been no changes of special importance in the processes worked in the office beyond that in intensifying negatives we seem at last to have succeeded in doing away with the bad-smelling hydro-sulphate of ammonia for intensifying, and have replaced it by a solution of—

	Parts.
Hyposulphite of soda	30
Liquor ammonia	60
Glycerine	20
Water	1,000

This change will effect a very considerable saving in expense, the full amount of which cannot yet be estimated.

The method has the defect that the films become very tender when dry, and will not bear handling; but this appears to be obviated by coating them with a mixture of albumen and gelatine—

	Parts.
Gelatine	20
Water	500

and the whites of two eggs.

I have also found a method of intensifying which appears likely to be useful for special half-tone work.

The collodion plate, after exposure and development, is intensified slightly with pyro-gallic acid and silver or iron and silver, and, after washing, plunged into a solution of bromide of copper at 10°/₀, which at once changes the colour of the film to a light canary yellow. It is then placed in a bath containing the ordinary ferrous-oxalate developer. This speedily darkens the colour of the film to a dark olive green, which becomes darker and darker up to a certain point by leaving the plate immersed in the solution. It is then taken out, washed, and dried. If not intense enough, the operation may be repeated, but the colour of the image is much more non-actinic than it appears. I have since found that instead of the bromide of copper, Carey Lea's solution of—

	Parts.
Saturated solution of bichromate of potash...	3
Hydrochloric acid	1
Water	48

may be used: it is almost equally effective, and much cheaper.

In the photo-transfer printing some exceedingly good results have been obtained by using an enamelled paper highly glazed with gelatine as the basis of the transfer prints. The paper is sold by the Autotype Company as a transfer paper for pigment printing. It can either be sensitised as it is in a bath of bichromate of potash, or be coated with a thin solution of gelatine and bichromate. In some cases the best results are obtained by inking in with a roller on the damped gelatine surface, but on the whole the usual method of inking in and washing seems to answer best. A small supply of this paper has lately been received from England; but being more thickly coated with gelatine than that I brought out with me, has not given very good results for large maps, where the sections have to be joined, though for work within the limit of a single negative it will be very useful.

We have made several trials of inking in the transfers with velvet rollers, as done at Vienna and Woolwich, but have not been able to obtain better results than we usually get either by washing or by rolling up with an ordinary lithographic roller. The latter, in cases where the work is very fine, is exceedingly useful.

Collotype.—I should have been glad to have been able to start this process again, but we have had few subjects for which it could be used with advantage, and more attention has been paid to heliogravure. The press obtained from M. Poirier seems exceedingly good for the purpose, and as soon as opportunity offers I hope to return to this process.

Heliogravure.—During the year I have given as much attention to this process as other demands on my time allowed. Two plates taken from original drawings in Indian ink of trap-crystals have been reproduced by the process, and upwards of 800 copies of each printed for publication in the Records of the Geological Survey of India; four other similar plates are in hand. A plate of coins was reproduced for the Asiatic Society, but not published. A reduction of a sheet of the Atlas of India was also done as an experiment.

More might have been done, but, apart from interruptions from other work, I have been trying to perfect an improvement which I found resulted from using tissue glazed with collodion. Owing to the fine smooth surface of this tissue the gelatine reliefs obtained with it are very much sharper in the details, and develop much clearer than they do with unglazed tissue; and this is particularly important in map and other line work, where absolute sharpness of the lines and a clean ground are imperative. Unfortunately, the collodion surface is apt to split away from the copper in drying; and in the electrotyping bath the copper solution gets underneath it and forms irregular deposits.

I have tried a great many ways of overcoming this difficulty and of obtaining the same advantages in some other manner, but the results as yet are not altogether satisfactory.

Substantially, the process is the same as I was working before I went on furlough; but the experience gained during my stay in Europe, from what I saw at Vienna and Florence, and from independent work at the Autotype Works at Ealing, has been of immense use, and the improvements I have now introduced seem to have put the process on a practical footing, though it still requires perfection in certain points. It appears therefore desirable to give a full description of the whole process, as I am now working it.

Before going into details, it may be briefly stated that the process consists in obtaining by the ordinary pigment-printing process a photographic image in relief on a polished and silvered copperplate. This relief is formed of insoluble gelatine, and, if it is of a half-tone subject, has its surface roughened or grained while wet by means of waxed sand or emery, which is removed when the relief is dry. It is then black-leaded, and copper is deposited on it by the electrotyping process, so as to produce a copperplate,

on which the design is reproduced in intaglio, with lights and shades of varying depths, corresponding to the gradations of tint in the original.

The pigment tissue.—The pigment tissue consists of paper evenly coated with a mixture of gelatine and any suitable pigment. As a rule, it is purchased ready prepared from the Autotype Company. Their engraving black, warm black, and standard brown tissues, all answer well.

The prepared tissue keeps fairly well, but it is an advantage to have it as fresh as possible, otherwise the gelatine surface becomes more or less insoluble by keeping, especially in damp weather, and forms a dark scum over the picture.

Sensitising.—The tissue is sensitised by immersing it in a solution of—

Bichromate of potash	1 ounce.
Alcohol	5 „
Liquor ammonia	½ drachm.
Water	25 ounces.

In the hot weather this solution must be cooled with ice.

The bath keeps well, but should not be used if it appears at all brown.

The tissue is laid in this for a minute or two, till it softens, and is then taken out and laid evenly down on a glass plate, and the excess of moisture removed with a squeegee or glass rod. It is then lifted off the glass and placed in the drying-box to dry.

To obtain the most perfect sharpness in the reliefs, it is desirable that the tissue should be dried so as to have a very highly polished surface, which will lie in perfectly close contact with the negative. This is best obtained by drying it in contact with a plate of glass, but the latter must be coated with some substance which will permit the tissue to be readily stripped off when dry; and in this there is a good deal of difficulty.

In Vienna the glass plate is rubbed with powdered French chalk, but this I have found very uncertain in its action when used with tissue sensitised as above: so are wax, stearine, and paraffin. Linseed oil varnish answers well, so does cocoanut oil; but a certain amount of the fatty substance is taken up by the tissue and diminishes its adherence to the copperplate support, so that it is liable to lift and blister in the after processes.

The substance I have found answer best in many ways is collodion, which has very distinctive advantages in the sharpness and cleanness of the images developed upon it; but on the other hand, it also has the grave defect noticed above of splitting on the plate, and the grain in half-tone subjects is not so well brought out as on uncollodionised tissues, collodion being one of the best preventatives of reticulation or the natural graining of the gelatine which occurs in hot weather.

The best way of using collodion is to thoroughly clean a piece of patent plate glass, rub it with a little powdered French chalk, then coat it with a moderately thin and absorbent collodion containing—

Pyroxyline	1 part
Alcohol	50 „
Ether	50 „

and allow this to become perfectly dry.

The collodion being dry, the glass plate is immersed in the sensitising bath along with the tissue, and the latter is drawn out with the gelatine side in contact with the collodionised surface and pressed closely down to it with an Indian rubber squeegee, which removes all excess of fluid. The plate is put into a drying-box, which may be moderately heated, till the tissue is dry. This generally takes two or three hours.

Some writers recommend that the collodionised glass should be put in water as soon as the collodion has set, and washed till all appearance of greasiness is gone, and the wet sensitised tissue applied to the wet surface of the collodion. I have not found this answer so well as allowing the collodion to dry thoroughly. It may, however, answer with suitable collodion.

The tissue being dry the edges are cut round, and it should readily leave the glass plate and show an evenly smooth and brilliant surface. Pieces of the required size are cut from it with the aid of a properly squared glass plate.

The varnish prepared by the Autotype Company for the transfer of pigment prints also answers very well in giving a good glazed surface and allowing the dry tissue to be easily removed, though the image does not develop so clearly as with collodion, and the varnish is rather brittle and liable to crack in removing the tissue, the cracks showing on the finished plate. The way of applying the varnish is much the same as with the collodion, the glass plate being coated with the varnish, allowed to dry, and the wet tissue squeegeed down upon it.

Exposure to light.—The tissue being cut of the proper size is laid on the negative in the printing-frame, so that the image may be square and correctly centered on it, and is exposed to light in the usual way under a *reversed* negative; the time varying in diffused light from about 5 to 10 minutes for line subjects, to 10, 15, or 20 minutes, or longer, for half-tone subjects, according to the density of the negative, strength of light, &c. An actinometer may be usefully employed, as in ordinary pigment-printing; but the light in this country being generally bright, time is a sufficiently near guide to the proper exposure.

Development of the image.—The exposed tissue is taken out of the printing-frame and immersed in perfectly cold water (in hot weather ice must be used to cool it), drawn out again

quickly in contact with and squeegeed well down to a polished copperplate which has been lightly silvered with a solution of nitrate of silver in cyanide of potassium, the object of the silvering being to prevent the adherence of the deposit of copper in the subsequent operation of electrotyping. Care must be taken to lay the tissue down squarely and in its proper place on the copperplate, and the squeegeeing is best performed by laying the plate and tissue down on a wooden support standing in a trough.

The superfluous moisture being wiped off the back of the tissue and edges of the plate, they are set aside for about 10 minutes, and then placed in clean warm water, just about as hot as the hand can bear it comfortably. After a few minutes the paper support of the pigmented tissue will be loosened, and may be removed, leaving a black, slimy-looking mass on the plate. By leaving the plate to soak a little longer in the water, gently moving it from time to time to wash away the dissolved gelatine, the image will gradually appear and the development may be finished by dashing the warm water over its face with the hand till the details all appear clear and the soluble gelatine is all removed. Should the image be too dark from overprinting, the use of warmer water in the later stages will lighten it up. In any case it is desirable that the ground of a line drawing or the highest lights of a half-tone subject should appear in bare copper ; but in this country there is great difficulty in avoiding a slight scum of gelatine.

After development the plate is rinsed in cold water, and may sometimes be lightly brushed over with a soft brush to remove any loose soluble gelatine or pigment still adhering to the plate. If a line subject, the plate is now drained and wiped at the back and along the borders to remove as much water as possible, and then plunged into a bath of strong spirit of wine. This at once contracts the gelatine forming the lines, and gives the latter a crispness it is difficult to obtain in any other way.

With some tissues the use of alcohol will also give a rough velvety surface and a certain amount of grain. Three or four years ago I found an alcoholic solution of tannin most useful in giving grain and the required hardness to the film ; but with the tissues now manufactured by the Autotype Company, I find it of no use at all in graining, though it tans the gelatine and hardens it. It causes, however, scummy markings which are difficult to remove, and on the whole I do not now recommend its use.

At Vienna, line subjects are first dried off and then soaked in a solution of bichromate of potash at 5% for about half an hour; they are then rinsed in water and dried slowly without heat. This is a very good plan, but in the hot weather I find that the reliefs run if left to dry slowly, and therefore quick drying off with spirit is better. The bichromate bath may, however, be used with advantage after the drying off with spirit.

For half-tone subjects, the treatment is quite different. After rinsing in cold water, the developed picture is first placed in a bath of bichromate of potash at 5% and allowed to remain for about half an hour. The superfluous bichromate is then washed out under the tap, so as only to leave that absorbed by the gelatine.

The object of the bichromate bath is to harden the gelatine relief and render it less liable to injury in the after process of graining, without at the same time making it too tough to receive the grain, as alum or chrome alum would do. The bichromate also seems to aid in the production of a good grain, either by a slight crystallisation in the gelatine or by some repulsive action exerted on the greasy graining powder.

Graining.—In order to produce proper prints of half-tone subjects in the copperplate press, it is essential that the different gradations of shade should be broken up into a grain consisting of a multitude of little points, which will ensure the hollows in the plate holding the proper amount of ink ; and it should therefore be comparatively coarse in the shadows, gradually becoming finer, in proportion as the tints become lighter, till it disappears entirely in the high lights. The obtaining of such a grain in a simple way has been the great difficulty in the way of photographic engraving processes for many years past, and various methods have been proposed from time to time to overcome it. In most of these methods the grain obtained is uniform throughout, monotonous and unduly prominent, while others more successful are trade secrets.

Whilst working at the Autotype Works at Ealing in 1881, I had the good fortune to hit upon a method of giving the gelatine reliefs a graduated grain, which is quite novel and seems very efficient. It consists in sprinkling over the surface of the gelatine relief, while still wet and soft after development, a granular powder, such as fine sand, emery, or glass powder, previously coated with some greasy material, such as wax, paraffin, or stearine, to prevent its ultimate adherence to the gelatine. As the gelatine dries, the powder is drawn into it, and naturally sinks deepest into the darkest parts, where there is most gelatine; less into the half-tones, where there is less gelatine; and not at all in the lights, where there is no gelatine. In this way the surface of the gelatine image on the copperplate is pitted all over, and takes a fine granular texture, following exactly the lights and shades of the picture.

Were plain sand or emery used, it would stick to the gelatine and it would be impossible to remove it. In the course of experiments at Ealing, I found that these granular powders could be coated with sufficient greasy or insulating material to enable them to be easily removed from the gelatine without in any way interfering with their granular character. Paraffin and wax answer well, but I have generally used stearine. Cocoanut oil would probably do equally well.

The choice of granular material depends very much upon the kind of grain required Graining sand of 160 holes to the inch gives a very clean open grain, rather too coarse for very fine subjects. Emery powder, 160 holes, gives also a good grain, but flatter, and not

so clean cut as the sand. Oakey's glass powder No. 1 gives a delicate, clean-cut grain suitable for very fine work. On the whole for general purposes I prefer the grain given by Oakey's coarse flour emery well washed to remove all dust.

The washing is done by placing a quantity of the powder in a long glass jar, which is filled up with water; the powder is well stirred up and allowed to settle for a minute or two, till all the coarser grains are precipitated; the dirty water is poured off, and the process continued till the water remains fairly clear. The coarse flour emery requires about 20 washings of 1 to 1½ minutes each to clear it; glass powder requires about 12 washings of 1 minute each; fine graining sand also requires several washings to take out the dust.

The powders washed as above are dried with heat in an iron or copper bowl, and when perfectly dry and still hot are stearined by shredding a little stearine into them and stirring well until it is melted and thoroughly incorporated with the powder. The pot is then taken off the fire, and the powder kept well stirred till cold. The grains should then be perfectly separate, and to all appearance the same as before being stearined.

The proportion of stearine is not of much consequence; from 4 to 6 or 8 grains to the ounce of powder are sufficient. The coarse flour emery takes about 4 or 5 grains to the ounce; 160 holes sand, rather more.

The washing of the granular powder is a very essential point in getting a clear sharp grain. I found that the dust confused the image in a very peculiar manner, and was very difficult to remove.

The graining powder is most conveniently applied with a small tin pepper-box, the lid of which is covered with fine wire gauze, instead of the usual perforated plate. The powder is well sprinkled all over the image, and the plate is set aside to dry in a horizontal position, being left for some hours, in order that the bichromate in the film may thoroughly harden it. The loose powder is then brushed off with a stiffish small paint-brush, and being returned to its receptacle can be used over and over again. The plate is now placed in a dish of cold water, and the remaining powder is removed by very gentle rubbing with a soft brush or the finger, till all feeling of grit has gone. The presence of powder will also be easily seen by reflected light. The powder should come away quite easily, and if it does not, more stearine must be added to it.

The plate is then well rinsed in cold water and gently brushed with a soft brush to remove all loose grains of powder, and set aside to dry. When dry, the margins are cleaned and the plate is ready to be electrotyped.

The plate should now show a finely-grained image in very low relief, and this image should as nearly as possible be an exact reproduction of the original in depth of light and shade and general appearance, while there should be sufficient gelatine to give an image of the proper depth when slightly swollen in the electrotyping bath.

Electrotyping.—The first thing to be done is to give the gelatine a conducting surface by brushing it over with plumbago. This must be done very thoroughly, and the plumbago must be good; otherwise there may be difficulty in getting a deposit of copper on the deep shadows. Gilt or silvered plumbago are useful; and it is a good plan to facilitate the adherence of the plumbago by breathing on the image. Where the shadows are very heavy, the relief may be rubbed over very lightly with a greasy pad; but this treatment is apt to give flat images by the grease preventing the slight rising of the gelatine relief in the battery.

The form of battery I have found most useful for electrotyping these reliefs is the single cell arrangement used in the Military Geographical Institute at Vienna, and also at Florence. While on furlough I worked up the use of this battery, particularly as to the best material for the porous diaphragm, and found that leather may be advantageously used to replace the paper parchment used at Vienna, which is easily liable to damage and not always procurable.

The battery consists of two wooden troughs fitting into one another. The inner has a porous bottom, and contains a zinc or iron plate lying in dilute sulphuric acid; the outer contains a saturated solution of sulphate of copper, and in it is placed the plate bearing the gelatine relief. This is suitably connected with the zinc or iron plate in the inner trough above it, and receives a deposit of copper, which being removed when of the proper thickness forms the printing plate.

The inner trough is a tray with wooden sides about 4 inches deep. Over the bottom of it a piece of leather is stretched tightly and nailed down with copper nails. The edges of the leather and the corners of the trough are painted over with electrical cement, so as to prevent leakage except by permeation through the leather. For the starting trough with zinc, I use kid skin, and for ordinary deposition with iron, sheep's skin. Along the ends of the trough, inside, are ledges about half an inch thick for the zinc or iron plates to rest on.

The outer trough is about 5 or 6 inches deep, and I prefer to make it long enough to permit the plate bearing the relief to be passed underneath the inner trough without the latter being lifted up. This enables the state of deposition to be easily examined at any time. The trough is best lined with lead, well pitched over; but good cementing with electrical cement answers well for small troughs. The solution of sulphate of copper contained in the trough is kept at saturation by crystals of sulphate of copper placed in a perforated box at one end of the trough. This box should be lined with flannel or cotton cloth to prevent dirt going into the trough.

The plate bearing the gelatine relief is supported on a copperplate coated with electrical cement on both sides, but furnished on the upper side with studs about ¼ inch long, the points of which are kept bright in order to produce electrical contact with the under side

of the relief plate. One side of the supporting plate has a stout copper band about 8 inches long riveted to it and carrying at the other end a connecting screw.

In this manner the plate bearing the gelatine relief is left quite free, and can easily be removed for examination or cleaning, while the electrical contact is quite sufficient for all purposes.

Before starting a plate, the solution of sulphate of copper is carefully filtered into the outer trough. A zinc plate, about the same size as the plate to be copied, and having a copper band soldered to one side of it, having been amalgamated in the usual way, is wrapped up in thin cotton cloth and laid in its place in the inner trough with kid skin bottom. All being ready, the supporting plate is laid in its place at the bottom of the outer trough, the plate bearing the black-leaded gelatine relief is laid upon it and just allowed to soak in the solution of sulphate of copper, while the inner trough with plate is placed in position and filled with the proper quantity of dilute sulphuric acid, containing one part of acid to 60 of water, so as to cover the zinc to a depth of about one-fourth inch. The copper band attached to the zinc is then fastened in the connecting clamp attached to the supporting plate in the lower trough, and the electrical circuit being complete the deposition should begin at once.

All working well, the gelatine relief should be completely covered with copper in the course of an hour or two, and may then be changed into the ordinary depositing trough, which is exactly the same thing, but with an iron plate instead of zinc, and sulphuric acid one part to 40 of water. I generally allow the plate to remain in the zinc battery all night, and then change to the iron battery in the morning. While depositing, the plate is washed every morning to remove dirt; and if any lumpy nodules or other irregular deposits should form on the face of the deposited copper, they are removed by filing. The iron plate is washed, and the acid renewed every other morning. As a rule, the deposition proceeds very evenly and regularly, at the rate of from 1½ to 2 ounces a day on a 10 × 8 plate; so that a plate of this size, weighing 1½lb, takes from 12 to 18 days to deposit. The whole arrangement is exceedingly simple and easily worked by a native assistant. I find it a great improvement over the Smee's battery I formerly used.

When the deposited copper is sufficiently thick, the outer surface is smoothed with a rubber file, and the edges being filed round, the deposited plate can easily be removed from the relief plate. Any gelatine adhering to the plate is washed out, the edges are trimmed, and the surface being polished with a little of the finest washed emery, or oil-rubbed, is ready for printing.

These plates generally require a little brightening up of the high lights with a burnisher, and, if necessary, deep shadows may be brought out by rebiting, or worked up with a roulette. At Vienna tints are sometimes deepened by applying a mixture of sulphur and olive oil with a brush. If due care is taken throughout, the original and negative good, and the tissue fresh, very little retouching should be required.

Before printing it is essential that the plates should be steel-faced, otherwise the fine parts will soon wear out.

Arrangements have been made for working larger sized plates, and I hope to report further progress during the ensuing year. The work is very much facilitated by the ease with which we now obtain reversed negatives by means of a silvered glass mirror placed behind the lens; and the new lenses and apparatus I obtained from Messrs. Ross & Co. while in England have proved very useful.

I have also given attention to other processes of photographic engraving in which the image is obtained by biting. These methods are quicker and more economical than electrotyping, but require more skill. Some of my experiments have shown fair promise of success, and I hope to find a method that shall be as far as possible automatic and require little aid from the skilled engraver.

Photographing on Copper.—An occasion having arisen when photographs of a drawing were required to be made on a copperplate as a guide to the engravers, I found a new way of photographing either line or half-tone subjects on copper, which is simple and likely to be useful.

The copperplate being cleaned and polished ready for engraving upon is dipped for a minute or two in a bath containing a ten per cent solution of bromide of copper; it is washed and allowed to dry, then exposed to diffused light for a second or two under a reversed negative or under the drawing itself, if suitable, and developed with the ordinary ferrous-oxalate developer used for gelatine dry plates and made by adding one part of a saturated solution of ferrous sulphate to three parts of a saturated solution of neutral potassio oxalate. The image soon develops in red on a greenish yellow ground. The plate is washed and the image fixed in a weak solution of cyanide of potassium, which clears and brightens the yellow ground. The resulting images are of a rich brownish purple on a canary-coloured ground.

It is in some ways an advantage to lightly silver the copperplates before sensitising them. The coating of bromide of silver is more sensitive, and develops better. The silvered plates should, however, be fixed with hyposulphite of soda.

Some of these plates, when etched with perchloride of iron, gave very distinct images, the perchloride attacking the shadows; but there is a difficulty in biting sufficiently deeply.

Gelatino-bromide plates and paper.—During the year I have worked a good deal with the new gelatine dry plates, with a view to see whether they could be usefully employed in the office in supersession of the wet collodion process. With some plates I have found no difficulty in working through the hottest weather, but the images obtained are not so

clear as with wet collodion; and I do not think that the gelatine would suit us so well as collodion, though it has many advantages in greater sensitiveness and convenience in manipulation.

Some of Morgan's argentic-gelatino bromide paper was obtained from England for trial, with the idea that it might be useful for reproducing cadastral maps. I found that it might be used very well for taking negatives in the camera, but the density was insufficient for photo-transfer printing. The paper might very usefully be used for making direct negatives by contact from originals drawn on fine tracing-paper, but not with our present originals, drawn on thick paper, and many of them dirty and stained. I drew the attention of the Meteorological Department to the paper as likely to be useful for the self-recording instruments. It was tried in the Observatory at Alipore, and found to answer so well that it has been definitely adopted in preference to the old waxed paper process. It saves a great deal of trouble and gives clearer results.

New Buildings.—A great deal of my time has been taken up during the year with the preparation of rough plans and drawings of the new buildings for the accommodation of the office, so very urgently required. A set of plans was made by Mr. E. J. Martin, the Government Architect, but they required considerable alterations, and there is still a good deal of work to be done in connection with the fittings and special appliances of a photographic office.

B.

Comparative Statement of the Out-turn of 1881-82 *with that of the previous year.*

	Ordinary Work.				Cadastral Maps.			
	1st October 1881 to 30th September 1882.	1st October 1880 to 30th September 1881.	Difference.	Difference in square inches.	1st October 1881 to 30th September 1882.	1st October 1880 to 30th September 1881.	Difference.	Difference in square inches.
Originals...	1,209	961	+299	.....	4,981	4,591	+390	.....
Negatives	1,848	1,278	+570	.....	3,624	3,576	+48	.....
Ditto square inches	607,890	376,960	.....	+230,930	2,783,232	2,741,776	.....	+41,456
Photographic transfers	1,818	1,273	+545	.....	3,655	3,762	−107	.....
Ditto square inches ...	606,254	391,808	.....	+214,446	2,807,040	3,192,816	.....	−385,776
Silver prints	533	558	−25	.....	.....	.....	.....	.....
Ditto square inches ...	59,792	97,418	.....	−37,626	.....	.....	.....	.....
Transfer to zinc (number of plates)	800	807	−7	.....	5,000	4,705	+295	.....
Number of pulls	99,047	84,546	+14,501	.....	109,990	127,424	−17,434	.....
Ditto of printed sheets (single)	125,318	225,076	−99,858	.....	109,990	127,424	−17,434	.....
Ditto ditto (combined) ...	107,329	209,444	−102,115	.....	49,579	83,102	−33,523	.....
Proofs	1,366	927	+439	.....	4,753	4,723	+30	.....
Transfers	1,089	890	+199	.....	4,922	4,760	+162	.....

C.

Statement showing the Amount and Value of the work done for other Departments and despatched between 1st *October* 1881 *and* 30th *September* 1882.

Names of Departments.	Number of sections.	Number of negatives.	Number of pulls.	Number of complete copies.	Number of silver prints.	Price.
						Rs. A. P.
Asiatic Society	4	5	1,125	1,500	.....	144 6 0
Agent and Chief Engineer, Bengal Central Railway Company, Limited	22	21	100	2,300	.....	402 11 0
Chief Commissioner, Assam	.....	.....	200	200	.....	69 0 3
Calcutta Municipality	6	2	350	1,000	.....	94 0 3
Director of Public Instruction, British Burma	3	8	3,015	1,000	.....	973 0 6
Director-General of Railways	5	8	2,403	778	.....	701 12 5
Deputy Superintendent, Census, Burma	.....	.....	500	500	.....	58 15 6
Geological Survey of India*	6	6	1,099	1,094	.....	394 12 1
Government of India, Foreign Department	7	20	1,030	484	.....	693 10 7
Ditto ditto, Public Works Department, Irrigation	29	31	1,275	2,775	.....	527 6 5
Ditto ditto, Military Department	27	27	736	1,222	.....	640 2 6
Government of Bengal Public Works Department ...	64	125	7,454	7,555	6	3,438 11 11
Ditto ditto, ditto ditto, Railway ...	4	7	280	320	.....	142 9 6
Government, N.-W. P. and Oudh, Public Works Dept., Irrigation	23	23	1,200	4,000	.....	451 13 3
Inspector-General of Military Works	123	21	6,880	5,105	.....	3,106 8 0

* Two heliogravure plates not charged, printing being done in Copperplate Printing Branch.

Statement showing the Amount and Value of the work done for other Departments and despatched between 1st October 1881 and 30th September 1882—continued.

Names of Departments.	Number of sections.	Number of negatives.	Number of palls.	Number of complete copies.	Number of silver prints.	Price. Rs. A. P.
Indian Museum	.....	.....	.....	.....	61	19 1 0
Secretary to the Chief Commissioner, British Burma ..	4	22	1,030	400	.....	583 13 9
Meteorological Reporter to the Government of India ...	6	4	463	463	.....	125 11 6
Marine Survey Department	10	27	3,855	2,350	.....	1,179 14 8
Manager Tirhoot State Railway	7	8	200	350	.....	154 5 6
Ditto, Indus Valley State Railway	3	.....	600	600	.....	180 7 6
Ditto, Rajputana-Malwa ditto	2	2	220	220	.....	72 9 9
Ditto, Northern Bengal State ditto	2	.....	250	500	.....	51 2 0
Officer Commanding Darjeeling Depôt	1	1	.....	.....	21	41 8 0
Port Officer	5	6	630	330	.....	201 4 0
Quarter-Master-General in India	5	11	2,785	1,933	.....	656 4 9
Secretary to the Defence Committee	5	20	250	250	.....	401 6 6
Ditto to the Port Commissioners	4	14	510	500	.....	325 8 6
Superintending Engineer, Mysore	1	9	360	70	.....	204 3 9
Ditto ditto, on special duty, Bengal	2	7	250	150	.....	169 2 6
Sanitary Commissioner, Assam	1	2	170	170	.....	54 12 3
Colonel A. A. Kinloch	.....	.....	.....	.....	4	6 0 0
T. Bolton, Esq.	1	1	600	200	.....	94 3 9
Total ...	382	433	40,716	40,223	92	16,531 4 4
Cadastral North-Western Provinces (Photo-zincographs) ...	1,743	1,743	17,550	11,990	.....	26,793 0 0
Ditto ditto (Zincographs)	551	.....	5,522	5,895	.....	5,653 2 0
Ditto Burma (Photo-zincographs)	1,611	1,611	54,774	20,356	.....	26,163 14 0
Ditto ditto (Zincographs)	825	.....	28,050	9,022	.....	9,310 3 0
Ditto Bengal (Photo-zincographs)	104	104	3,792	955	.....	1,696 5 0
Ditto ditto (Zincographs)	1	.....	50	50	.....	78 4 0
Ditto Assam (Photo-zincographs)	16	16	400	325	.....	244 0 0
Total Cadastral ...	4,856	3,479	110,161	49,193	.....	69,835 15 0
Grand Total ...	5,238	3,917	150,877	89,416	2	

D.

Statement of Expenditure of the Photographic branch and of the Value of the work done and issued during the survey year from 1st October 1881 to 30th September 1882.

Normal Establishment.	Rs. A. P.	Rs. A. P.
Superintendent's salary	13,577 9 1	
Establishment	12,076 7 11	
House rent and taxes	4,483 8 0	
Contingencies	1,628 3 10	
		30,363 12 10
Cadastral Establishment.		
Establishment	19,204 7 1	
Contingencies	6,291 6 4	
		25,695 13 5
Chemicals and stores received from England	13,048 9 7	
Paper received from England	9,353 7 3	
		22,402 0 10
Paper and map cloth from the Stationery Office	432 8 0	
Stores and materials from the Stationery and other Government Offices	220 14 2	
		653 0 2
Stores received from the Mathematical Instrument Department	254 15 9	
Cost of repairs of articles at ditto ...	289 1 0	
		544 0 9
Miscellaneous stores received from other branches	20 8 4	
Printing paper received from Lithographic branch	4,464 7 2	4,484 15 6
Balance in favour of the Department ...	.....	21,648 11 1
Grand Total ...	.....	1,14,794 12 7

	Rs. A. P.	Rs. A. P.
Topographical and Revenue maps and other maps and plans issued to the Surveyor-General's and the Deputy Surveyor-General's Offices	28,300 7 6	
Miscellaneous work done for the other branches of the head-quarters office	127 1 9	
Miscellaneous extra-departmental maps and plans	16,531 4 4	
		44,958 13
Cadastral maps, North-Western Provinces	32,478 2 0	
Ditto British Burma ...	35,414 1 0	
Ditto Bengal	1,009 12 0	
Ditto Assam or Sylhet ...	244 0 0	
		69,835 15 0
Grand Total		1,14,794 12 7

J. WATERHOUSE, *Major*, S.C.,
Asst. Survr.-Genl., in charge Photographic Branch.

Extract from the Narrative Report of J. B. N. HENNESSEY, ESQ., M.A., *Deputy Superintendent, 1st grade, in charge Head-Quarters Offices, Trigonometrical Branch, Dehra Dún, for* 1881-82.

COMPUTING BRANCH.

Computing Branch.

THE following cost table of work done in this Branch is similar to the corresponding tables exhibited in the reports for previous years :—

Cost Tables in Rupees.

CLASS.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Average per cent.
1. Records, Library	24	46	54	23	22	25	63	22	21	36	27	32	1¼
2. Computations	371	571	602	531	664	748	484	529	718	555	423	419	26
3. Accounts, returns, correspondence	483	322	261	238	230	264	390	332	403	467	543	509	17¾
4. Supply	39	35	46	33	18	45	21	54	63	75	19	42	2
5. Press copy	236	228	219	235	339	424	224	167	137	321	257	149	12
6. Press proofs	213	191	167	190	146	251	190	160	221	176	214	207	9
7. Charts	14	9	47	28	14	59	34	9	34	53	33	11	1
8. Stations	90	52	53	127	171	64	74	105	196	59	56	91	4½
9. Leave and vacations	183	286	575	472	337	64	263	176	9	61	147	84	10½
10. Miscellaneous	...	...	...	...	...	...	...	...	92	59	173	184	5½
11. Meteorology and General Science {	448	402	108	210	201	268	334	547	...	...	...	...	10½
... ...	...	...	...	...	...	...	...	...	183	200	245	414	
TOTAL ...	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	2,142	10

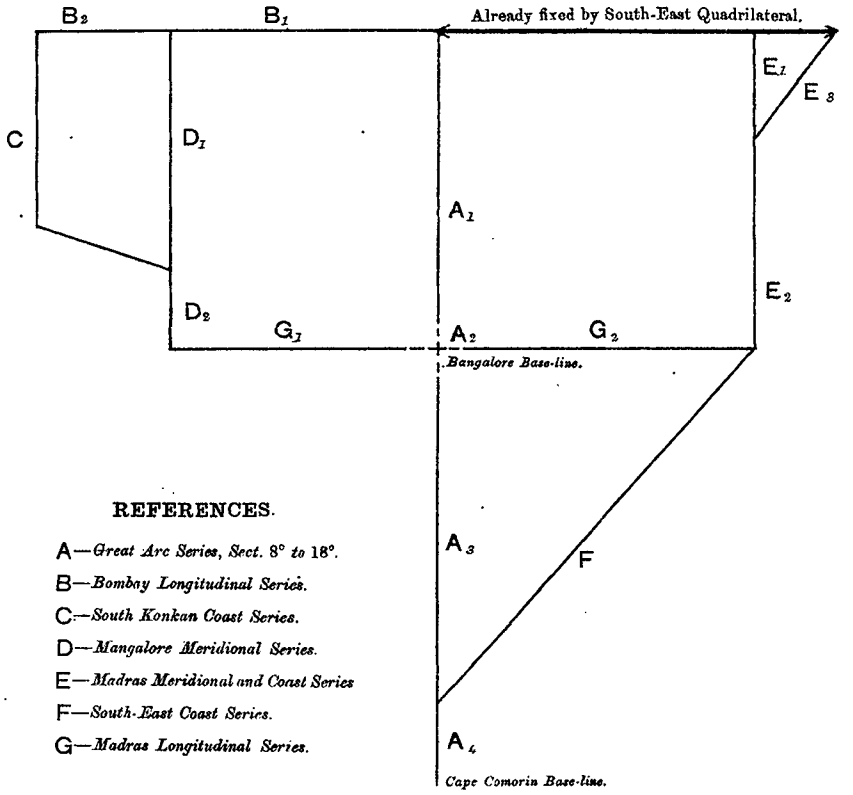
These percentages call for little remark, being about the same as in previous years, excepting in the case of class 6, which in the present return shows an average of about half the usual amount. It is also to be noticed that an additional class, viz. 11, has been introduced for the first time, it having hitherto been included in class 10—Miscellaneous. The average of the new class is unavoidably approximate on the present occasion, for the subdivision was adopted only in June. The percentage, however, is now seen to be sufficiently large to make the change desirable.

The particulars of the work done, indicated in a general manner in the preceding table, are given hereafter in such detail as appears desirable.

CLASS 2.—COMPUTATIONS (IN DUPLICATE).

Southern Trigon.—The simultaneous reduction was continued without interruption from the stages reported on last year as finished, and was concluded satisfactorily in due course. The following table states the 22 equations of condition, which may be followed with the help of the diagram, and the errors as given and as found after elimination. It will be seen that the residuals are very small.

SOUTHERN TRIGON.



REFERENCES.

A—*Great Arc Series, Sect.* 8° *to* 18°.
B—*Bombay Longitudinal Series.*
C—*South Konkan Coast Series.*
D—*Mangalore Meridional Series.*
E—*Madras Meridional and Coast Series*
F—*South-East Coast Series.*
G—*Madras Longitudinal Series.*

Error Table.

Number of equation.	Triangulation involved.	Value of Errors.			
		Given.	By substitution of "Indeterminate factors."	By substitution of deduced angular errors.	Residuals after computation with corrected angles.
				As computed to four decimals.	On contraction to three decimals.	
1	in side	$(E_2 + O) - D_1$	+ 136·6	+ 136·600	+ 136·6644	+ 136·661	— ·3
2	„ λ	Ditto	+ 0·022	+ 0·0220	+ 0·0212	+ 0·0218	— ·003
3	„ *L*	Ditto	+ 0·078	+ 0·0780	+ 0·0773	+ 0·0778	+ ·002
4	„ *A*	Ditto	— 0·251	— 0·2508	— 0·2508	— 0·2507	— ·002
5	„ λ	$[E_1 + (D_1 + D_2) + G_1] - (A_1 + A_2)$	— 0·001	— 0·0010	— 0·0009	— 0·0008	+ ·003
6	„ *L*	Ditto ditto	+ 0·283	+ 0·2830	+ 0·2864	+ 0·2878	+ ·003
7	„ *A*	Ditto ditto	— 3·650	— 3·6500	— 3·6877	— 3·6505	+ ·003
8	„ side	Ditto $+ A_2$	— 22·7	— 22·705	— 22·7551	— 22·760	+ ·3
9	„ „	$A_1 + A_2$	+ 20·0	+ 19·969	+ 19·9659	+ 19·993	+ ·3
10	„ λ	$A_1 + A_2 + G_2 - (E_1 + E_2)$	0·000	0·0000	— 0·0033	— 0·0003	+ ·006
11	„ *L*	Ditto ditto	— 0·174	— 0·1740	— 0·1711	— 0·1737	+ ·001
12	„ *A*	Ditto ditto	+ 4·303	+ 4·3027	+ 4·2845	+ 4·3029	·000
13	„ side	$(E_1 + E_2) + G_2 + A_2$	+ 39·9	+ 37·931	+ 40·2144	+ 39·980	+ ·3
14	„ „	$A_2 + G_2 + F + A_4$	+ 21·5	+ 21·493	+ 21·2959	+ 21·503	·0
15	„ „	$(A_2 + A_3 + A_4)$	+ 1·1	+ 1·094	+ 1·0925	+ 1·097	— ·1
16	„ λ	$(A_3 + A_4) - (G_2 + F)$	— 0·273	— 0·2729	— 0·2719	— 0·2728	— ·005
17	„ *L*	Ditto ditto	+ 0·424	+ 0·4240	+ 0·4234	+ 0·4233	— ·004
18	„ *A*	Ditto ditto	— 9·040	— 9·0393	— 9·0211	— 9·0184	·000
19	„ side	$E_1 - E_2$	+ 11·7	+ 11·700	+ 11·6165	+ 11·695	·0
20	„ λ	Ditto	— 0·042	— 0·0418	— 0·0462	— 0·0419	·000
21	„ *L*	Ditto	— 0·001	— 0·0011	+ 0·0029	— 0·0007	+ ·002
22	„ *A*	Ditto	— 0·319	— 0·3195	— 0·3253	— 0·3189	+ ·003

NOTE.—The units of this table are—in side, the seventh place of logarithms; and in λ, *L*, and *A*, a second of arc.

The exhibits of this table assume the completion of the usual after-computations of triangles λ, *L*, and *A*, which are included in the following statement:—

Triangles up to log feet	360
Auxiliary figures	7
Second deductions of λ, *L*, and *A*	200
First deductions of latitudes and longitudes (chiefly for supplying data for longitude work)	30
Compound figure, Ceylon Series	1

The compound figure last mentioned presented some peculiar features. It was originally ground in the ordinary way as *two* figures, *i.e.* a quadrilateral and a hexagon, of which only some triangles presented unusually large errors, amounting to over 6 inches; but it could be seen that the whole of these errors may be accounted for by assuming the displacement of a single ray at but one of the two stations *common* to the two figures. Moreover, these two stations were unavoidably only $\frac{3}{4}$th mile apart; and as the sites were subject to high winds while the drops for the plumb-lines were considerable, there was every reason to suppose that improved results would be secured by rejecting the ray in question. This was verified by actual computation, and the displacement detected; but the reduction of a compound figure of the kind, it will be found, presents some special difficulties.

Observed Latitudes.—The amount of progress has unavoidably been less than desirable, though quite commensurate with the working power available. On the one hand the mass of observations is considerable: there are 906 stars in all, and several pairs of these

have been observed at 117 stations (including revisits). On the other, the nature of the work has not hitherto admitted of employing more than one pair of computers: even these two were required for still more pressing computations, so that their services have been diverted from the latitudes for five months out of the past twelve. In fact, two computers have been on loan to field parties for three-fourths of the year.

Notwithstanding interruptions, sensible progress has been made. Having exhausted the information in all available catalogues, (provisional) places and variables were adopted for the remaining 106 stars (epoch 1850), and from these the required sub-epochal values for years of observation were found. The facts of the place-table, *i.e.* N. P. D., precession, secular variation, and proper motion, were then suitably abstracted for the whole of the 906 stars. This enabled the computers to enter on the next stage, *i.e.* finding the latitude from each concluded zenith distance (or Z). In arranging for this end, every advantage will be taken of the components already computed by the field parties, as reduction to *apparent* N. P. D. (or Δ), refraction, collimation, &c., &c. Though, however, these components are mostly forthcoming, it is necessary that they should first be suitably combined before the successive values of Δ and Z can be exhibited. This, with entries of results, comparison against duplicate records, correction of mistakes discovered, &c., require great care and circumspection, which are not compatible with rapid execution. Notwithstanding, the required entries have been deduced and made for some 40 stations, and are now under comparison.

Besides foregoing, a table has been put in hand by which the adopted values of Δ (or provisional place) may be checked hereafter.

N.-E. Quadrilateral.—North-East Longitudinal Series, Assam Valley Triangulation, and Ganges River Triangulation between Mirzapur and Chunar.

Main Series	Triangles computed	18
	Deductions of latitude, longitude, and azimuth computed	24
	Weights of angles, computed	54
Secondary	Triangles, adjusted and computed	477
	Traverse of 57 triangles, computed and adjusted	1
	Deductions of latitude, longitude, and azimuth, computed or corrected	660
	Extra azimuths, computed	92
	Heights, corrected	325

Volume VII.—Various tables prepared for incorporation in the sections of this volume.

Computations for Colonel Tanner of work in and around Gilgit.—Computed 448 secondary triangles; 310 deductions of latitudes, longitudes, and azimuths; and 110 deductions of heights; 15 deductions of azimuth and side from given latitude and longitude; besides a variety of miscellaneous work in the way of examining angle books, preparing abstracts and synopses, &c. (Occupied a pair of computers, 3½ months.)

Computations for Colonel Branfill, Colonel Campbell, Majors Rogers and Hill, in connection with the Mergui base line, and latitude and azimuth observations, the Eastern Frontier Series and Burmah Party operations, and the electro-telegraphic longitude work.—The calculations, &c., are of so very miscellaneous a character that it would be tedious to detail them. They occupied a pair of computers five months in all.

Incidental computations.—Connected chiefly with supplying of data called for by various officers, including the calculation of 65 deductions of side and azimuth from given latitude and longitude (for Major Holdich), the calculation of 26 deductions of principal latitudes and longitudes for Mr. Beverley, &c., &c. (Occupied a pair of computers half a month.)

The amount of assistance in computations and otherwise necessarily required by field parties was considerable: it is approximately indicated in foregoing. Notwithstanding this help, various field operations unavoidably remain to be reduced, including the measured length of the Mergui base line.

Class 3.—Accounts, Returns, Correspondence.

As mentioned in last year's report, the designation of this class is more general than special, to avoid undesirable increase in the adopted number of classes. Briefly, a considerable portion of the work embraced in this class is of a purely professional nature, presenting much variety in kind.

Class 4.—Supply.

Requisitions from over thirty officers for data of various kinds have been complied with. Amongst the officers so supplied were Major Bailey, R.E., Superintendent of Forest Surveys, and Mr. J. H. Fisher, in charge Provincial Gazetteer, North-West Provinces. 1,135 despatches of maps, charts, books, &c., were made during the year.

Class 5.—Press Copy.

Southern Trigon.—The compilation of Descriptions of Stations (Principal) for publication has been gone on with so far as practicable. The abstracts of angles have been finally compared and now stand complete. In the reduction of figures some further recomputation was necessary, and this has been done.

Electro-longitude, or Volume IX.—Certain portions of tabular matter have been transcribed and compared; also the press copy as received has been examined generally.

Latitude Volume, or Volume X.—Major G. Strahan prepared various drawings of Strange's Zenith Sector, and Colonel Campbell wrote an account describing the instrument

and how to use it. These were examined and discussed. Subsequently, the drawings were placed in the hands of the engravers (Surveyor-General's Office, Calcutta), and of the letter-press a few Provisional Prints were struck off in this office.

N.-E. Quadrilateral, Volumes VII and VIII.—Introductions to seven of the sixteen series forming this Quadrilateral were reported last year as passed to press: those to eight more have during the present year been completed, and considerable progress has been made with the only remaining introduction (viz. to the Assam Longitudinal Series). The tables of non-circuit triangles and of the final figural adjustments have been fully compared. Vocabulary of native words prepared. Addendum to Descriptions of Principal Stations compared for 10 series. Rough draft prepared of section 19, volume VII, describing and comparing certain differences in details of processes adopted in the reductions of the several quadrilaterals. Volume VII completed in all respects, and sent on to binder.

Synoptical Volume of Assam Longitudinal Series.—Azimuth table extended to include work of 1876-78 (wants recomparison); Co-ordinate list extended so as to include *part* of work of 1876-78 (wants completion and comparison).

Synoptical Volume of the Gurwani Series.—Extended Co-ordinate list to include Ganges River Triangulation between Mirzapur and Chunar.

Eastern Sind Series.—Partly abstracted, and compared observed angles and reduction of figures. Prepared letter-press of Eastern Sind Series, Preliminary Chart (seasons 1879-81); this needs comparison in part Prepared and compared letter-press of Sehwan Series, Preliminary Chart (season 1880-81).

Assam Valley Triangulation.—Compiling letter-press for Preliminary Chart of seasons 1876-78.

Bangkok Triangulation.—Prepared and compared tabular portion of letter-press for Preliminary Chart.

Spirit-leveled Pamphlet No. 4, Southern India.—Examined generally and corrected orthography; addendum prepared, giving a *précis* of the reduction by minimum squares of the levels between Bombay, Karwar, and Madras; and the corrections required by this reduction introduced into the press copy (wants comparison before publication).

Route Book, 3rd edition.—Examined the additions and corrections to former edition.

Miscellaneous.—Arranged (alphabetically) a list of names for Mussooree cemetery plan, and checked it against the inscriptions.

Class 7.—Charts.

Final	...	Compared Calcutta Meridional Series and addendum to Gurwani Series. Corrections examined in Hurilsong Series.
Proliminary	...	Compared Assam Valley triangulation, season 1876-78. Ditto Eastern Sind Series, season 1879-81. Ditto Sehwan Series, ,, 1880-81.

Miscellaneous.—Assisted Colonel Branfill in plotting Preliminary Charts of Eastern Sind Series (1879-81) and Sehwan Series (1880-81). Examined generally diagrams for level sheet No. 82, and fair drawing to illustrate Pamphlet of Spirit-levels No. 4, Southern India. Examined and corrected orthography in a list of names occurring in Atlas Reduction of sheet No. 2, Dehra Dún survey. Examined chart of portion of the North-East Longitudinal Series, prepared for Captain Harman's use. Examined delineation (on Preliminary Chart of Pegu, Rangoon, and Coast Series) of coast line along the Irrawaddy delta, and of the traverse from below Rangoon to connect the Krishna shoals with the triangulation. Compared two charts, showing portions of the triangulation in Burma, prepared for the Marine Survey. Examined several diagrams for volume of Electro-Longitudinal Operations; Skeleton Chart of Principal Chains of Triangles, and the frontispiece for volume VII. Entered correct values of Spirit-leveled and Railway Heights on several sheets of the Kattywar Survey for second edition. Examined Plan of the Mussooree cemetery. Prepared rough working-charts of Ganges River Triangulation from Mirzapur to Chunar, and of two minor series emanating from the Assam Valley Triangulation.

Class 8.—Stations.

The increased percentage for this class makes it desirable to give a few particulars as in the following table, indicating the amount of work annually devolving on this office in carrying out the important duty of protecting our principal stations for the benefit of all future surveys: the table also shows what has been done in past years towards enabling the local officers to recognize the stations in question:—

Number of stations.	Number of districts in which stations occur.	Number of lists in which the stations are included.	Duplicate (i.e., finally disposed of) lists.		Number of lists sent out from this Office during the year.		Number of Local Officers who have—		Number of stations protected during the year.	Number of bills audited and passed.	Total cost.	Average cost per station.	Number of letters, dockets, &c., issued.
			Number of lists.	Number of stations included.	New.	Supplementary.	Reported during the year.	Not reported during the year.					
3,472	333	317	310	3,458	.....	8 descriptive of 27 stations.	263	51	761	216	Rs. 3,433	Rs. 4-8	About 500

Under existing orders, District Officers and Political Agents are authorized to expend for the protection of each station a sum not exceeding on an average Rs. 4 per annum; any outlay in excess of this amount cannot be incurred by them without special authority from this office. The officers are also required to report annually on the condition of the stations, and as a rule this duty is discharged efficiently: on the present occasion it will be seen that there are 54* exceptions, or about 17 per cent.

Class 10.—Miscellaneous.

Volumes of the G. T. Survey.—Volume VII, pages examined, sorted, and despatched to Calcutta for binding. Synoptical Volumes VII, X, XI, XII, and XIII, distributed.

Examination papers.—Six sets prepared for examination of candidates for Junior branch of the Department, and the workings of four candidates examined.

Time observations.—Forty-two sets of observations to the sun (on 14 days) for time taken, and reduced in duplicate.

Examined and reported on the Annual Report (MS.) of the Kattywar Party for 1880-81.

Examined and reported on Mr. Rendell's account of the crossing of the line of spirit-levels over the Hooghly by simultaneous observations of Tide heights on both banks.

Examined and reported on Major C. Strahan's form for the calculation of Interpolated points.

Reported on (and corrected in some cases) heights on certain 5-minute compartments of India sent in by field parties.

Examined and reported on (1) Crellin's Traverse tables; and (2) Mackesy's tables for the calculation of Barometric heights.

Devised and prepared specimen forms for reduction of Southern Trigon.

Cost table prepared for the several scales of survey on the Kashmir, the Kumaun, and Garhwal, the Dehra Dún, and the Jaunsar-Bawar Survey operations.

Discussion of assimilation of certain office forms for the three branches of the survey.

Examined proposed symbols for maps.

Deduced Telegraphic longitudes of seven stations for comparison with Geodetic.

Set up stage at Mussooree Observatory for new large Anemometer, and mounted the instrument.

Mergui base line.—The preparations for this base line, measured in 1881-82 under the supervision of Colonel Branfill, necessarily caused a considerable amount of care and labour to this office in general. The apparatus had not been used for twelve years, so that the whole of the instruments required at least cleaning and adjusting, while several needed repairs; and other portions, as trestles, had mostly to be constructed anew for the occasion. It was also necessary to revive recollections of the art, which, like others, does not improve with disuse; nor were the difficulties diminished by the fact that the old base line *native* establishment, if not officers, had of course become very scarce. In addition to the arrangements above briefly indicated, provision was also made, by preparation of suitable books, for the field records of the measurement.

Class 11.—Meteorology and General Science.

Meteorological Observations.—Taken at Dehra twice on every day of the year, and at Mussooree during about seven months. The results for Dehra have been supplied month by month to the Meteorological Reporter to Government, North-Western Provinces and Oudh; and daily weather telegrams from Mussooree (for some seven months), as well as the anemograms for both Dehra and Mussooree, have been supplied to the Meteorological Reporter to Government of India. The usual tables of monthly results and of the mean velocity of the winds at Dehra are appended.

Earth temperatures.—These observations are briefly introduced in the report for 1880-81, and further particulars as to procedure would be redundant or out of place here. The series, moreover, has as yet been continued for only one and a half years, so that detailed discussion

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* Note.—Of these there are—

In the Punjab	4	In Bombay	5
,, North-Western Provinces ...	12	,, Madras	5
,, Bengal...	2	,, Central Provinces	2
,, Sind	1	,, Native States	23

would be premature. It may, however, prove useful to give the monthly mean temperatures obtained, and these are accordingly exhibited in the following table:—

Mean Monthly Readings of Deep-sunk Earth Thermometers.

Year and Month.	Depths in feet of thermometer bulbs below surface of ground.					Thermometer in shade.
	25·6	12·8	6·4	3·2	1·1	
1881.						
June	73° 55	74°·87	80°·66	85°·23	89°·16	87°·68
July	75°·90	76° 47	81°·01	85° 19	84°·14	85° 54
August	75°·02	77°·53	80°·75	82°·03	82°·25	81°·00
September	76°·07	76°·98	81°·24	82°·40	83°·19	82°·56
October	76°·09	79°·26	80°·33	79°·07	77°·81	82°·72
November	76°·98	77°·71	76°·80	72°·20	67°·81	76°·22
December	76°·71	74°·89	70°·58	65°·63	60°·73	71°·39
1882.						
January	75°·91	72°·33	67°·17	62°·57	55°·91	66°·77
February	75°·13	70°·79	66°·06	62°·31	59°·41	66°·13
March	74°·52	70°·47	67°·75	61°·01	59°·50	81°·36
April	74°·11	71°·70	72°·29	75°·49	78°·88	86°·78
May	75°·97	73°·37	76° 47	80°·86	84° 99	91° 04
June	74°·05	75°·23	80°·01	84°·77	88°·24	89°·11
July	74°·31	76°·57	80°·78	83°·71	83°·45	81°·61
August	74°·95	76°·29	81°·30	83°·04	84°·06	82°·40
September	75°·60	76°·98	81°·32	82°·20	82°·59	84°·62
October	76°·14	79°·02	80°·16	79°·21	77°·85	83°·47
November	76°·39	77°·64	76°·75	71°·73	67°·96	75°·04
December	76°·37	74°·89	71°·03	66°·14	62°·17	72°·36

Note.—The second places of decimals are purely arithmetical outcomes.

Contrasting to the following extent the Dehra results for 1882 with the means for Greenwich 1847–1873:—

Depth.—Feet.	1882 ... ... Dehra (or D) ...		Lat. ... Long. ... Height ...	30° 19′ 78° 3′ 2,200 ft.	1847–1873 ... ... Greenwich (or G) ...		Lat. ... Long. ... Height...	51° 29′ 0° 0′ 200 ft.	D–G.		
	Minimum.		Maximum.	Range.	Minimum.		Maximum.	Range.	Minimum.	Maximum.	Range.
6·4	Feb. ... 66°·06	Sept.	... 81°·32	15°·26	Feb. ... 41°·81	Aug.	... 56°·63	14°·85	21°·26	21°·67	0°·41
12·8	March ... 70°·47	Sept.	... 78°·98	8°·55	March ... 44°·80	Sept.	... 53°·77	9°·34	24°·04	23°·25	− 0°·79
25·6	May ... 73°·97	Oct.	... 79°·02	5°·05	April ... 46°·43						
		Nov.	... 76°·39	2°·63	May ... 48°·96	Nov.	... 52°·22	3°·27	21°·02	24°·17	− 0°·61
		Dec.	... 76°·37		June ... 45°·16						

So far as it goes, the result is curious. It may be added that the two greater depths at Dehra indicate lower maximum temperatures in 1882 than in 1881.

Actinometry.—The necessity for this work, and the eligibility of certain localities in India as stations of observation, are now so fully recognised, that the Secretary of State, co-operating with the Solar Physics Committee, South Kensington, has sent out Sergeant Rowland, R.E., in order that he may be instructed to take a series of observations, extending over at least two years, at Leh, in Kashmir. Sergeant Rowland landed in India on 1st November 1882, so that it is anticipating events to allude to him before next report. The allusion, however, is necessary in order to explain briefly my connection with actinometry, and that the Meteorological Reporter to Government, H. F. Blanford, Esq., F.R.S., has found it convenient to place the Sergeant under my orders here pending his departure to Leh.

Some 15 years ago the Royal Society placed certain instruments suited for high altitude at my disposal, for use in my leisure hours, including two of Hodgkinson's actinometers. I commenced using these in 1869 at Mussooree, where the brilliant weather, especially in autumn, admits of excellent work. Subsequent observations with these instruments, and recently with a Stewart's actinometer, were made from time to time and published in the Proceedings of the Royal Society,* together with my discussions of the results and earnest representations that the most important work of actinometry should be vigorously prosecuted. The work performed by "a sunbeam," at any rate on this globe, from "propelling a locomotive" to governing the commonest events of life, is of vital importance to us all; and it is certainly a matter for astonishment that one of the most powerful of solar forces, radiation, should remain so little measured as it is.

* No. 125 of 1870.
" 208 of 1880.
" 220 of 1882.

In consequence of these actinometric observations, I have acquired familiarity with the work, which at first was *all* done entirely in leisure hours; but as the subject became more attractive and appreciated, it was necessary to obtain some help from my assistants, and hence to show, as has been done in the cost table, the percentage due to this, as well as to kindred scientific duties in which the office is called on to co-operate. My opportunities for using the actinometer are necessarily limited to the fine weather which may occur during my residence at Mussooree in summer. The work is still done largely in leisure hours, but the opportunities are only few in number under the circumstances. The results, however, help to indicate what should and may be done, and are likely to prove useful guides. Apart from

this, the proceedings of the Royal Society also show what facts have been elicited, but their repetition here would be out of place. The actinometer was used a few days last summer and again in autumn ; but I have had no leisure as yet to discuss the results.

Solar eclipse, 1882, *May* 16-17.—This happened at Mussooree to the considerable extent of about eight digits. It occurred to me that with the help of a *continuous* actinometrical series an attempt may be made to measure *variations* of radiation in *different* parts of the sun's surface. The project was carried out, but the sky and sun were covered with light clouds throughout, so that the results are vitiated. The negatives taken with the photo-heliograph at Dehra present a complete and interesting series.

Exploration.—After an absence from India of about three years, explorer M— S— returned with a valuable traverse of various routes in and around Badakhshan. His journal and itinerary were arranged and translated in this office, and passed on for printing orders. Under the circumstances, a description is unnecessary here. The sketch map illustrating these travels was taken from a more comprehensive compilation prepared by Colonel Tanner: the sketch was examined and made consistent with the translation on which it depended.

TYPOGRAPHIC BRANCH.

The usual table showing the work annually performed by this branch during the past five years is given below, the unit (a page of foolscap) being the same throughout :—

	1877-78.	1878-79.	1879-80.	1880-81.	1881-82.
Pages composed	2,050	1,841	1,421	1,363	1,283
„ printed	630,894	590,043	494,136	480,672	471,616

An analysis of the pages composed furnishes the following :—

	Pages.
For Professional Volumes VII and VIII	444
„ „ „ IX (Longitude Volume)	290
„ „ „ X (Latitude „ Provisional)	24
„ „ „ Southern Trigon	177
Total ...	935
For Volume of Kandahar and Khakrez Triangulation	42
„ Auxiliary Tables	9
„ Spirit-leveled Heights, No. 4, Southern India (since superseded for re-printing)	57
„ charts, orders, memoranda, forms, &c.	270
Total ...	348

PHOTOZINCOGRAPHIC BRANCH.

The following are the particulars of the work executed by the Photozincographing Branch during the year :—

Maps.

Subjects.	When published.	Number of parts.	Number of sheets printed.
Prints of maps published in former years	.....	30	3,870
Reserved forests, Bahraich *(for Forest Department)* ...	October 1881	1	300
Guzerat Survey, sheet No. 6	„ „	1	194
Sketch of Lower Dawar Valley	„ „	½	65
Ditto the Khaisor Pass Waziristan	„ „	½	65
Ditto the Waziristan Defile	„ „	½	65
Spirit-leveled heights, sheet No. 75	„ „	1	207
Index to the Darjeeling Survey	„ „	1	200
Reserved forests, Kumaon and Garhwal Division *(for Forest Department)*	„ „	1	322
Reserved and protected forests, Kumaon and Garhwal Division *(for Forest Department)*	November „	1	322
Reserved forests, British Burma *(for Forest Department)* ...	December „	1	453
Guzerat Survey, sheet No. 16	„ „	½	187
Cutch Survey, sheet No. 5	January 1882	1	142
Index to the Cutch Survey	„ „	1	463
Index to the Level Charts	„ „	1	466
Kumaon and Garhwal forest map, sheet No. XLVIII *(for Forest Department)* ...	„ „	1	67
Ditto, ditto, No. XLVII *(ditto)* ...	„ „	½	69
Ditto ditto, No. LXVII *(ditto)* ...	„ „	½	69
Ditto ditto, No. XIII *(ditto)* ...	„ „	½	67
Ditto ditto, No. LXIII *(ditto)* ...	„ „	1	70

Subjects.	When published.	Number of parts.	Number of sheets printed.
Index to the Guzerat Survey	January 1882	1	495
The Russo-Persian Frontier	,, ,,	1	156
Dehra Dún Cemetery	February ,,	1	22
Kumaon and Garhwal forest map, sheet No. XLVI *(for Forest Department)*	,, ,,	1	65
Spirit-levelled heights, sheet No. 82	,, ,,	1	109
Kumaon and Garhwal forest map, sheet No. XLIV *(for Forest Department)* ...	,, ,,	1	69
Ditto ditto, No. LXII *(ditto)* ...	,, ,,	1	72
Ditto ditto, No. LX *(ditto)* ...	,, ,,	1	73
Ditto ditto, No. XII *(ditto)* ...	,, ,,	1	67
Reserved forests, Bamunpokri *(for Forest Department)* ...	,, ,,	1	95
Kumaon and Garhwal forest map, sheet No. LXI *(for Forest Department)* ...	March ,,	1	67
Ditto ditto, No. LXVII *(ditto)* ...	,, ,,	1	70
Cutch Survey, sheets Nos. 3, 4, 10, and 11	,, ,,	1	135
Ditto, sheet No. 16	,, ,,	1	141
Trans-frontier map No. 9, 2nd edition	,, ,,	1	136
Guzerat Survey, sheet No. 17	April ,,	1	140
Cutch Survey, ,, No. 13	,, ,,	1	139
Ditto, ,, No. 14	May ,,	1	130
Guzerat Survey, ,, No. 33	,, ,,	1	180
Ditto, ,, No. 33, section 1	,, ,,	1	85
Ditto, ,, No. 34	,, ,,	1	194
Russian Turkestan, ,, No. 9 *(for Foreign Office)* ...	,, ,,	2	32
Guzerat Survey, ,, No. 77	,, ,,	1	206
Ditto, ,, No. 50, section 1 *(Dang Forests)* ...	June ,,	1	95
Ditto, ,, No. 49, ,, 5 *(ditto)* ...	,, ,,	1	115
Ditto, ,, No. 49, ,, 8 *(ditto)* ...	,, ,,	1	85
Ditto, ,, No. 34, ,, 1	,, ,,	1	86
Kohat Survey, plane-table, sections Nos. 1, 2, 3, 4, 5, 6, and two unnumbered sections	,, ,,	8	1,052
Map of Mussooree and Landour *(for North-Western Provinces Gazetteer)*	July ,,	1	714
Alexandria Harbour, plan of	,, ,,	1	80
Northern Waziristan	,, ,,	1	202
Southern ditto	,, ,,	1	278
Turkistan map, sheet No. 1 (provisional prints)	,, ,,	1	30
Ditto, ,, No. 3 (ditto)	,, ,,	1	28
Ditto, ,, No. 4 (ditto)	August ,,	1	
Guzerat Survey, sheet No. 33, section 3	,, ,,	1	90
Mussooree Cemetery	September ,,	1	57
Total ...	.....	103	13,471

In addition to the foregoing, 460 blue prints and 726 silver prints (146 subjects) were prepared for the use of executive officers :—

Charts.

Subjects.	When published.	Number of parts.	Number of copies printed.
Budhon Meridional Series, final	October 1881	1	407
Chart illustrating triangulation in Kattywar, degree No. IX ...	,, ,,	1	20
Kumaon and Garhwal forest triangulation, sheet No. III *(for Forest Department)*	January 1882	1	56
The Malabar Minor Series, season 1879-80	February ,,	1	69
Karara Meridional Series, final	March ,,	1	405
Reduction Chart of the Budhon Meridional Series, final ...	,, ,,	1	348
Eastern Frontier Series, season 1880-81, preliminary ...	April ,,	1	64
Hurilnong Meridional Series, final	May ,,	1	439
Calcutta Meridional Series, final	,, ,,	1	406
Chondwar Meridional Series, final	,, ,,	1	355
Eastern Sind Series, season 1879-81, preliminary	August ,,	1	67
Eastern Frontier Series, secondary triangulation to Bangkok, season 1879-80, preliminary	,, ,,	1	65
Western Coast of Burma, sheet No. 1 *(for Marine Survey)* ...	September ,,	1	50
Ditto ditto, No. 2 *(ditto)* ...	,, ,,	1	50
Northern Afghanistan	,, ,,	4	450
Sehwan Minor Series, season 1880-81, preliminary	,, ,,	1	69
Burmah Triangulation, Pegu, Rangoon, and Coast, showing also the traverse to the Krishna Shoals, seasons 1878-80, preliminary	,, ,,	1	88
Reduction Chart of the Jodhpur Meridional Series, final ...	,, ,,	1	78
Total ...	.....	21	3,486

Diagrams.

Subject.	When published.	Number of copies printed.
Polygons and other figures to illustrate figural reductions for volumes of the Great Trigonometrical Survey, bench-marks, &c. ...	October 1881	520
	January 1882	618
	February ,,	909
	March ,,	1,052
	June ,,	298
	July ,,	25
	August ,,	857
	September ,,	510
Total ...	.....	4,789
Professional and office forms	.....	24,987

The total number of negatives taken is 885, the number of chromo-carbon prints 1,089, and the number of transfers to zinc 189.

Contrasting the work performed since 1877-78, we have—

Year.	Maps.	Blue prints.	Silver prints.	Charts.	Diagrams.	Forms, &c.
1877-78	12,481	195	426	4,531	4,877	23,736
1878-79	20,229	1,394	353	2,642	2,603	20,070
1879-80	15,100	588	1,021	3,821	2,271	17,909
1880-81	15,659	414	52	1,886	3,367	19,508
1881-82	13,471	460	726	3,486	4,789	24,987

An abstract of the work executed during the past five years stands thus—

Subject.	Number of Prints.				
	1877-78.	1878-79.	1879-80.	1880-81.	1881-82.
Maps, charts, diagrams	21,889	25,474	21,192	20,912	21,746
Blue prints	195	1,394	588	414	460
Silver prints	426	353	1,021	52	726
Forms, &c.	23,736	20,070	17,909	19,508	24,987

The money actually realized and credited to Government from sales of maps, &c., during the year is Rs. 743-10-10.

DRAWING BRANCH.

The following tables exhibit the work performed in this branch :—

Description of Work.	Number of Sheets or Diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Final Charts.				
Brahmaputra Series	.....	1	4	For reduction by photozincography.
East Calcutta Longitudinal Series	1	.....	4	
Eastern Frontier Series	.....	1	4	
Calcutta Meridional Series	1	.....	4	
Ganges River Triangulation, for incorporation in Gurwani Series	1	.....	4	
Preliminary Numerical Charts.				
Assam Valley Triangulation, seasons 1876-78 ...	2*	.....	4	For photozincography.
Eastern Sind Series, seasons 1879-81	1*	.....	4	
Sehwan Minor Series, season 1880-81	1	.....	4	
Gilgit Triangulation	1	.....	8	For office record.
Burma Coast Line Triangulation, secondary, seasons 1878-80	1	.....	4	For photozincography

* The letter-press appertaining to these charts is not yet complete.

Description of Work.	Number of Sheets or Diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Compilation.				
Charts of the Western Coast of Burma, with hills (for Marine Survey)	2	.....	4	For photozincography.
Turkistan map, sheets Nos. 1, 2, 3, and 4 (6th edition) ...	4	.....	32	
Spirit-leveled height charts, sheets Nos. 67, 81, 83, and 88	.....	4	2	
Map of Jaunsar Bawar, with hills	1	.....	1	
Atlas reductions of sheets 2 and 3, Dehra Dún and Siwalik Survey	1	1	Atlas scale	For incorporation in atlas sheet No. 48.
Map of Astor and Gilgit with surrounding country ...	1	.....	4	For photozincography.
The Aglar Valley, portion of country between Landour and Nagtiba ranges	1	.....	2	For reduction by photozincography and incorporation in atlas sheet No. 48.
Trans-frontier map No. 9 (2nd edition)	1	.....	8	
Trans-frontier map No. 9 (3rd edition)	.....	1	8	
Map of country on North-Western Frontier ...	1	.....	4	For correction of atlas sheet No. 14.
Sketch map illustrating the explorations of M— S— in and around Badakhshan, 1878-81	.....	1	8	For reduction by photozincography.
Map of the Panjah (Upper Oxus) States and Dardistan	1	.....	8	For office record.
Routes for new addition of pamphlet to accompany Himalayan Route map	.....	.....	.....	
Skeleton chart of principal chains of triangles west of meridian of 92° (for professional volume VII) ...	1	.....	96	For reduction by photozincography.
Maps of parts of Arabia and Persia for the Resident in the Persian Gulf	.....	2	32	For photozincography.
Skeleton chart of principal chains of triangles as completed up to May 1882; also the proposed secondary triangulation in Upper Burma and in the Malayan Peninsula (for Surveyor-General's Annual Report to Government)	1	.....	96	For reduction by photozincography.
Map No. 4, Southern India, illustrating spirit-leveling operations of G. T. Survey, season 1880-81 ...	1	.....	12	Ditto ditto.
Chart of the principal chains of triangles included in the N.-E. Quadrilateral (for professional vols. VII and VIII)	1	.....	32	For reduction by photozincography.
Charts of the N.-E. Longitudinal Series (for Captain Harman, R.E.)	8	.....	4	For use of field party.
Miscellaneous.				
Tabulated mean heights above sea-level of 5-minute compartments in 54 degrees of latitude and longitude	.....	.....	.....	
Calculated the areas of Chamba State, Dehra Dún district, and the dominions of the Maharaja of Kashmír (for various officers)	.....	.....	.....	
Examined and corrected the following:— atlas reductions, Guzerat Survey, sheets Nos. 5, 6, 7, 8, 14, 15, 16, 25, 26, 27, 28, 29, 31, 78, 79, and 80; Kattiwar Survey, sheets Nos. 39, 40, 41, 49, 50, 52, 53, 54, 55, 56, 57, 58, 59, 60, and 61; Cutch Survey, sheets Nos. 3, 4, 5, 10, 11, 12, 13, 14, 15, 16, and 22 ...	.....	.....	.....	
Examined and reported on, corrected and passed for the press, 16 original maps of topographical surveys, excluding the above sheets	.....	.....	.....	
Examined 294 proofs of maps and charts; coloured 8,749 maps	.....	.....	.....	
Tabulated Dr. W. Griffith's heights in Afghanistan (for the Surveyor-General)	.....	.....	.....	
Plotted explorer M— S—'s route survey in and around Badakhshan	.....	.....	.....	For engraver.
Drew diagrams of zenith sector	.....	.....	.....	
Drew anemogram form (for recording velocity and direction of wind)	.....	.....	.....	For photozincography.
Drew actinometer observation curves	.....	.....	.....	
Prepared a tracing of level heights along Chenab river in Gujranwala district	.....	.....	.....	

Description of Work.	Number of Sheets or Diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Miscellaneous—concluded.				
Prepared two indexes showing level data in hand and data published (for office use)	.....	.....	.....	
Traced profile section of Bari-Doab Canal, 4th division (for level sheets)	.....	.....	.....	
Prepared tracing of Russo-Persian boundary east of the Caspian Sea (for Foreign Office)	.....	.....	.....	
Drew form for computation of interpolated points ...	.....	.....	.....	For photozincography.
Drew scale for pen equation (for longitude volume) ...	.....	.....	.....	For photozincography.
Extracted latitudes and longitudes of numerous places in several districts for Mr. Fisher's Gazetteer of the N.-W. Provinces	.....	.....	.....	
Corrected Atlas Sheets Nos. 67 N.E. and 13 N.E. ...	.....	.....	.....	For engravers.
Drew diagram of Cachar Branch Series (for professional volume VIII)	.....	.....	.....	For photozincography.
Prepared tracings of boundaries of several Hill States in the Punjab (for the Commissioner of Umballa) ...	.....	.....	.....	
Printed Plate III, Commutator Board (for longitude volume)	.....	.....	.....	For photozincography.
Drew diagram of ground thermometers	.....	.....	.....	
Compared 341 pages (royal size) of descriptions of bench-marks in Bareilly district (for Executive Engineer)	.....	.....	.....	
Miscellaneous current duties, including preparing for the press several maps of the topographical surveys and of the forest survey, transliterating Russian names, reducing maps by pantagraph, and affording assistance to officers and to the Photozincographic Office, &c., &c.	.....	.....	.....	

The preceding tables of the Drawing and Photozincographing branches present various points of general interest; a few of these are selected for brief notice:—

The Camera as an aid to the draftsman.—Provided the Field Executive and the Photographic Officer are able to act in concert, there can be no question of the enormous help the latter may afford the former in compilations, changes of scale, and the ability to recognise at once what details from a large scale map may be adopted without crowding in the reduction. In fact, unless the operation required be so trivial that it may be put out of consideration altogether, the advantages of the camera over the pantagraph are so obvious as to need no recommendation. That these advantages continue to be appreciated appears from the number of silver prints taken, amounting to 726.

Additional prints of maps already published.—These approached to 4,000, showing the maintained demand for publications of former years.

Prints, urgent.—Such as Russo-Persian frontier, Alexandria harbour, Russian Turkestan, Hill States, &c. Photozincography still holds its own, especially in supplying such pressing wants which it can meet with celerity and neatness not as yet otherwise equalled, notwithstanding that 24 years have elapsed since the process was discovered.

Local.—As Dehra cemetery, Mussooree cemetery, the former surveyed by a draftsman from this office, and the latter by Major J. Wilmer during recess: these maps have already been found very useful, and similar delineations would, no doubt, be valued at other stations, where opportunity for making them, it is hoped, may occur.

Spirit-leveled height charts.—Though more pressing work has interrupted the publication of these valuable records of work, done in and out of the Department, there are full four sheets in hand, besides that data for others have been collected to a certain extent in several districts in Bengal.

Various.—Kohat survey, Northern and Southern Waziristan, Mussooree and Landour for Gazetteer, a neat out-turn from old negatives, sketches of Lower Dawar Valley, Khaisor pass, and Waziristan defile, Astor, and Gilgit, &c., &c.

Forest Department.—The maps, 17 in number, and 1 chart, were all drawn, as usual, in the Forest Office, but published in the Survey Photozincographing press.

Charts and Maps.—Burma Western Coast for Marine Survey: Panja and Dardistan, Burma coast triangulation and traverse to Krishna Shoals, &c., &c.

Turkestan.—The compilation not having as yet been published, detailed notice would be premature. It may, however, be mentioned that the present will be the sixth edition of this map; that it has been brought up to date, and compiled, like its predecessors, under directions from the Surveyor-General.

CORRESPONDENCE AND STORES.

The year's correspondence is represented by 2,244 letters and office memoranda. Of instruments, &c., received and despatched, there were—

Instruments, despatched	464
Ditto received	399
Stores, articles received	416
Ditto despatched	509

presenting a total of 246 parcels and packages received and of 93 packages issued. The principal occasions of issue and receipt occurred in connection with the measurement of the Mergui base line.

SOLAR PHOTOGRAPHY.

Mr. L. H. Clarke, Surveyor, 2nd grade, has continued to work as Solar Photographer, with Mr. C. F. Guthrie as his assistant. The working facts for the year are given in the subjoined table :—

1881-82.	No. of Days.				No. of Negatives.						Number of Working Days when Solar Phenomena were—	
	When negatives were taken.	Failures. From bad weather.	Failures. From various causes.	Failures. Total.	Solar Phenomena. Spots and faculæ.	Spots only.	Faculæ only.	None.	Runs.	Total.	Visible.	Absent.
October	31	.....	.....	31	90	.....	.....	.....	26	116	31	.....
November	29	1	.....	30	94	.....	.....	.....	24	78	29	.....
December	30	1	.....	31	97	.....	.....	.....	26	123	30	.....
January	26	5	.....	31	93	.....	.....	.....	19	88	26	.....
February	27	1	.....	28	76	.....	.....	.....	20	96	27	.....
March	31	.....	.....	31	86	.....	.....	.....	25	111	31	.....
April	29	.....	.....	30	92	.....	.....	.....	25	117	29	.....
May	31	.....	.....	31	86	.....	.....	.....	23	116	31	.....
June	27	3	.....	30	74	.....	.....	.....	17	91	27	.....
July	20	11	.....	31	47	.....	.....	.....	8	55	20	.....
August	19	12	.....	31	82	.....	3	.....	17	72	19	.....
September	27	3	.....	30	75	.....	.....	.....	22	97	27	.....
Total ...	328	37	.....	365	900	.....	3	.....	257	1,160	328	.....

This table shows that during the period of 365 days the sun was photographed on 328 days; that 903 negatives were taken, of which only three exhibited faculæ alone, while the others (900) showed both spots and faculæ.

It will also be seen that 257 runs were taken. These runs are quite useless for this particular instrument as it stands. A run is intended to exhibit the accuracy of instrumental adjusting, and the exhibit is true only if *no* telescopic shift in declination occurs in the instrument between taking the two images. But the declination clamp of this instrument is faulty in design and weak in construction; nor can it be remedied without a break of some days in the series of negatives, for which there really is no justification. Thus the pernicious shift occurs when least expected, and the runs then show instrumental errors which in reality do not exist. In fact the adjustments are always maintained in perfect order. This I never omit to state in my weekly extracts from the diary sent to the Solar Physics Committee. It follows from what has been said that the runs are even worse than useless, for they may mislead, unless the caution in the diary be attended to. I have no doubt that the runs, as the instrument stands, should be discontinued, and I have urged this more than once without eliciting any reply from Mr. Lockyer, so that the runs continue to be taken. The instrumental adjustments are examined daily.

The following percentages relate to daily visibility of the sun and presence of features, *i.e.* spots and faculæ :—

Year.	In 100 days the sun was invisible on—	In 100 working days features were present on—
1877-78	9 days (obtained from 273 days) ...	30 days (obtained from 248 working days).
1878-79	11 „ 89 „ ...	28 „ 79 „
1879-80	14 „ 289 „ ...	82 „ 232 „
1880-81	15 „ 365 „ ...	96 „ 307 „
1881-82	10 „ 365 „ ...	100 „ 328 „

Contrasting the *percentages* of number of days of invisibility above given with those furnished by the Astronomer Royal's annual reports, we have—

Year.	At Dehra, year ending 30th October.	At Greenwich, year ending May.
1880-81	15	60
1881-82	10	45

So that on an average, from above, for one day of invisibility at Dehra about four occur apparently at Greenwich. In view of the gaps thus caused in the Greenwich series, the Astronomer Royal, in his report dated 20th May 1882, remarks :—"As regards solar photography, the value of our results would be very greatly increased if the gaps in the Greenwich series were filled up by the help of the photographs taken in India and elsewhere under the auspices of the Solar Physics Committee, so that the areas and positions of sun spots and faculæ should be given for every day."

The photographs at Dehra are, and have always been, taken on every day of the year, *including Sundays*, when the sun is visible: at Greenwich no negatives apparently were taken on Sundays until the beginning of September 1881.

Solar activity, as indicated by the presence of spots and faculæ, has been enormous during the year under report. No attempt is made here to find the positions and magnitudes of these features, as it is intended that this work should be done in England, so that weekly batches of my negatives are sent home for the purpose by the mail; and as now that the Dehra negatives are to be placed (as I am recently informed) at the Astronomer Royal's disposal, early publication with his own results may be expected.

A rare exhibit of sun spots occurred in 1882—April 13 to 26—the Dehra negatives of which were fortunately obtained complete without a break. If, to distinguish between the two halves of the sun, we denote the visible half by *earth-face* and call the other half *reverse-face*, I think it will be found that the majority of spots, not insignificant, burst out (or occur) on the latter face, so that their first appearance to us is on the sun's edge. Now whether earth-face or reverse-face spots are most potent in producing terrestrial effects can hardly be inferred from magnitudes alone, which may possibly continue to be visibly great for a time after the force which caused them has passed its maximum. Anyhow, a distinction between the two kinds of spots appears desirable. I therefore notice of the outburst or exhibit in question that, regarding them as three groups, numbered from east to west, No. 1 was a reverse-face group, and somewhat the largest; No. 2 was insignificant as a reverse-face group, but after considerable progress across (with) the earth-face it burst out and grew prodigiously, until it almost rivalled No. 1, besides that a relative displacement happened apparently between the two: the behaviour of No. 3 was somewhat similar to that of No. 2, but on a vastly smaller scale. Thus Nos. 1 and 2 present very remarkable groups of the two kinds of spots indicated, the former being a reverse-face and the latter essentially an earth-face group; and this rare combination suggests enquiry as to relation in time between these spots and (at least) the magnetic disturbances which are known to have occurred in their presence. In addition to the negatives taken, 879 silver prints were made from them. The negatives and prints have been regularly despatched weekly to the India Office.

The secondary magnifier for the old photo-heliograph, for enlarging the sun's image from 4 to 8 inches, was received during last monsoons, when the weather was too unsettled to admit of substituting the new for the old tube without great risk of break in continuity of series. This substitution was effected later on, and 8-inch negatives taken until the 18th December 1882, when, however, in accordance with a letter from General Strachey to the Surveyor-General, reversion to 4-inch negatives (with the old instrument) was effected. Negatives of the latter size are intended for the Astronomer Royal.

The new large photo-heliograph for 12-inch negatives came to hand safely in the end of last July, when it was set up for the purpose of ascertaining its dimensions exactly, in view of constructing a suitable building and dome for its reception. This necessary observatory is now being pushed on with the utmost vigour, and will, I hope, soon be finished. I much regret that its completion should have been delayed by circumstances beyond my control.

The sunshine recorder continues to act efficiently; too much so for evidence of opportunities when sun photographs may be taken, for the recorder may declare the sun to be present when for purposes of photography he is practically invisible.

Monthly Meteorological Results taken from the Register kept at the Head-Quarters Office, Trigonometrical Branch, Survey of India, Dehra Dún.

YEAR AND MONTH.	BAROMETER.						HYGROMETER.				THERMOMETER.								RAIN.		WIND.	CLOUD.	
	At 9-30 A.M.			At 3-30 P.M.			At 9-30 A.M.		At 3-30 P.M.		Dry Bulb.					Wet Bulb.							
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean temperature of dew-point.	Monthly mean humidity.	Monthly mean temperature of dew-point.	Monthly mean humidity.	Maximum in sun's rays.	Minimum on grass.	Maximum in air.	Minimum in air.	Monthly mean in air.	Maximum wet.	Minimum wet.	Monthly mean wet.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 9-30 A.M.	At 3-30 P.M.
1881.																							
October	27·813	27·504	27·606	27·726	27·441	27·579	58·1	·592	58·5	·471	105·1	45·3	85·5	54·5	71·4	75·8	50·0	62·1	1	·97	Calm	.....	1
November	·875	·641	·771	·771	·578	·684	42·5	·564	46·4	·396	94·4	34·3	78·8	44·8	62·9	65·6	40·3	53·2	.....	.....	.....	.....	1
December	·924	·729	·832	·827	·655	·739	40·9	·539	42·1	·376	83·2	28·6	73·5	39·5	57·5	59·5	34·4	48·6	.....	.....	N.	2	2
1882.																							
January	·958	·699	·833	·839	·613	·746	45·8	·709	47·2	·518	89·0	31·1	74·3	38·7	57·1	69·6	37·0	50·6	4	3·19	W.N.W.	4	5
February	·963	·513	·738	·812	·403	·659	45·5	·696	43·4	·458	92·4	31·6	74·3	37·2	56·4	60·0	35·6	49·5	6	2·14	W.	4	5
March	·850	·407	·628	·762	·362	·607	48·4	·477	46·1	·312	109·3	37·4	89·4	44·3	63·3	69·4	41·7	56·1	3	·44	N.	2	5
April	·693	·485	·593	·605	·383	·496	48·5	·369	44·6	·246	112·6	43·2	96·7	50·7	75·9	73·5	46·7	59·6	3	·90	.....	2	4
May	·698	·381	·531	·606	·281	·427	54·7	·336	53·3	·309	119·0	54·3	101·1	60·7	80·2	79·2	49·9	64·8	3	2·67	W.	1	3
June	·546	·281	·383	·474	·190	·305	69·1	·625	69·7	·538	119·3	63·1	100·4	67·6	82·9	80·5	61·9	72·8	16	8·10	Calm	5	6
July	·457	·277	·395	·425	·217	·325	73·6	·821	74·6	·779	110·8	67·5	88·8	70·0	79·0	79·8	67·8	74·3	25	31·15	.....	8	8
August	·570	·182	·434	·529	·092	·360	73·3	·891	74·5	·768	109·0	64·8	88·7	68·5	79·2	80·1	66·6	73·8	21	17·22	.....	6	8
September	·671	·436	·550	·561	·345	·466	70·0	·726	71·4	·654	108·6	61·3	89·8	67·2	78·0	77·4	63·8	71·3	8	·53	W.	3	5

NOTE.—The height of the barometer cistern above mean sea-level at Kurrachee is 2,232·41 feet.

Mean Velocity in Miles of the Winds which blew at Dehra Dún during the twelve months of 1881-82 *for each Hour of the Day.*

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
0 to 1	·67	·54	2·77	2·61	2·68	3·19	2·93	1·68	1·47	·53	·74	1·77
1 „ 2	·23	·18	2·60	2·53	2·35	2·97	3·47	2·00	1·43	1·13	1·00	1·90
2 „ 3	·37	·36	2·10	2·52	2·18	2·68	2·70	2·10	1·30	1·23	·84	1·37
3 „ 4	·17	·25	2·17	2·32	2·18	2·71	2·80	1·90	1·13	·97	·80	1·10
4 „ 5	·13	·18	2·27	2·00	1·93	2·45	2·23	1·84	1·33	·93	·61	1·27
5 „ 6	·10	·07	2·06	2·16	2·04	2·35	2·50	1·71	1·07	1·23	·65	1·10
6 „ 7	·07	·07	2·27	2·13	1·75	2·03	1·77	1·35	·83	1·17	·87	1·07
7 „ 8	·00	·11	1·60	1·71	1·89	1·52	1·43	1·45	1·10	1·03	1·94	·83
8 „ 9	·03	·04	1·17	1·48	1·68	2·19	1·80	2·19	1·47	1·48	1·87	1·13
9 „ 10	·00	·11	1·00	2·00	2·25	2·29	3·20	3·55	2·00	1·93	2·42	1·90
10 „ 11	·20	·25	2·03	2·58	2·64	2·52	4·33	4·00	2·53	2·03	2·13	2·27
11 „ 12	·43	·75	2·53	3·16	3·04	3·68	5·17	4·16	2·67	1·71	2·26	2·63
12 „ 13	·83	·67	2·55	2·74	3·48	4·06	4·67	3·65	3·30	1·57	2·48	2·70
13 „ 14	·77	·96	2·55	2·71	4·04	4·35	5·57	4·29	3·50	2·23	3·06	3·07
14 „ 15	·93	·81	2·77	3·16	3·96	4·39	5·40	4·45	3·37	2·65	2·61	2·83
15 „ 16	·50	·63	2·29	2·94	4·18	4·39	4·87	4·19	2·93	2·23	1·94	2·90
16 „ 17	·30	·15	1·19	2·26	3·75	3·68	4·50	4·32	2·67	1·81	1·07	2·77
17 „ 18	·03	·11	·90	1·42	2·29	2·61	3·20	3·10	1·97	1·57	1·19	1·23
18 „ 19	·50	·26	1·90	1·55	1·14	1·61	1·90	3·68	1·37	·93	·74	·43
19 „ 20	·97	·70	2·42	1·87	1·61	2·42	2·43	2·71	1·20	·70	·31	·83
20 „ 21	·70	·78	3·13	2·06	2·29	3·23	3·20	2·97	1·73	·69	·87	1·27
21 „ 22		1·22	3·10	2·06	2·29	2·90	3·07	2·55	1·77	·43	1·13	1·37
22 „ 23	·37	·96	3·13	2·45	2·36	3·84	3·27	2·26	1·40	·50	1·00	1·63
23 „ 24	·20	·07	2·84	2·10	2·37	2·90	3·20	1·71	1·47	·80	1·03	1·50
Sums ...	10·03	10·53	53·01	54·57	60·35	70·96	79·01	63·91	45·01	31·97	35·06	41·17
Average ...	·42	·45	2·25	2·27	2·51	2·96	3·33	2·67	1·88	1·33	1·46	1·72

W. H. D'C.—Reg. No. 9747J—491—22-6-83.

Circular No. 408.

Extract from the Proceedings of the Government of India, in the Revenue and Agricultural Department (Surveys),—dated Simla, 1st June 1883.

READ the General Report on the Operations of the Survey of India during the year 1881-82, submitted with the letter from the Officiating Surveyor General of India, No. 1084 of the 17th April 1883.

RESOLUTION.

FOLLOWING the order observed in reports of previous years, the first chapter of the Report deals with the triangulation work of the year. The chain of principal triangles, known as the Eastern Frontier series, which in previous years had been carried from Assam through Arakan and British Burma into Tenasserim, was completed: thus was brought to a close the principal triangulation of all India on the lines marked out in 1830 by Colonel Everest. Opportunity is taken of this fact by the Surveyor General to give an interesting history of the undertaking, from its inception almost single-handed by Major Lambton in the first year of the century. The maps accompanying this section well illustrate the principles on which this great work has been built up. As regards the secondary triangulation still to be done, the Surveyor General reports that a great deal is required on the coast lines to furnish fixed points for the marine surveys, and in localities in the interior at a distance from the nearest principal chains, where data may be required for topographical purposes. It is also wanted outside the limits of India proper on the North-Eastern Frontier to furnish a basis for the geography of Upper Burma, and southwards in the direction of Singapore.

2. The next chapter deals with topography. Thirteen topographical parties have carried on their regular work in continuation of that of last year, and chiefly in the same provinces. The parties were thus distributed:—three in Rajputana and Central India, four in the Bombay Presidency, and the remaining six in Assam, Mysore, Kohat, Beluchistan, Meerut, and on the Hooghly river. Following the above order, the work of each party may be briefly noticed. The party employed in Rajputana worked for the most part in the Jodhpore State and completed an area of 5,611 square miles. It has now been transferred to British Burma, and the part of country remaining to be surveyed has been made over to the Gwalior and Central India Survey party for completion. This latter party surveyed during the year the three Rajput States of Marwar (Jodhpore), Meywar (Oodeypore), and Sirohi, embracing an area of 2,440 square miles, of which 460 square miles are described as being "about as difficult and intricate as could well be found." The work of the Bhopal and Malwa party fell chiefly in the territories of Banswarra, Oodeypore, Pertabgarh, and Dangarpur, most of which is said to be very hilly, wild, and intricate country. In addition to the standard scale of topography, two cities—Banswarra and Jaora—were surveyed on the scale of 6 inches = 1 mile; the total area surveyed amounted to about 1,096 square miles. The greater part of the party has now been transferred to Mirzapur to complete the topography of that district which is required in connection with the cadastral survey operations now in progress there, and the completion of the survey of Malwa has been assigned to the Khandesh party.

3. The four Bombay parties were respectively employed in Guzerat, Khandesh, Cutch, and the Southern Collectorates of the Deccan. In Guzerat four descriptions of work were carried on:—

(i) The ordinary topographical survey of Native States, executed on the 2-inch scale and published on the 1-inch scale.

(ii) The preparation of a series of maps on the 2-inch scale, comprising British territory in detail, and foreign territory in skeleton; and for the former utilizing the maps of the Bombay revenue and settlement surveys as far as practicable.

(iii) The 4-inch scale of the Dang Forests.

(iv) The survey of the city, cantonment and environs of Surat on the 12-inch scale.

This party has done very good work during the year, and has now brought the total surveyed area of the district up to about 15,683 square miles, leaving about 14,850 square miles (or about half the district) yet to be completed. The Khandesh party surveyed an area of 1,554 square miles out of the 2,650 square miles which remained for completion at the close of the previous year, thus leaving only another season's work for the party. The area surveyed by the Deccan party includes a portion (130 square miles) of the Nizam's Dominions. This portion had to be surveyed, as there are no maps of the tract forthcoming in the records of the Hyderabad survey. The Cutch survey was conducted in a similar manner to that of last year.

4. Of the other six topographical parties, the Assam one was employed in surveying the lower spurs of the Tipperah Hills running northwards past the British boundary into the plains of Sylhet, as well as the group of low hills which lie between Fenchuganj and the Manu River. These tracts are now becoming very valuable, as they are being taken up and opened for tea cultivation. In Mysore the party completed an area of 4,226 square miles on the scale of 1 inch to 1 mile. The Kohat party surveyed some very intricate ground lying in the upper valleys of the Kohat and Teri rivers, and also the Surdag and Lawaghur Hills with the low lying plains at their foot on the west of the Bannu District; and the Beluchistan party did a fair amount of work, chiefly in the country lying between Quetta and Khelat.

The chief work of the North-Western Provinces party was to survey the Meerut and Bulandshahr Districts on the 2-inch scale. The riverain tract along the Ganges and the Jumna in Bulandshahr was, however, surveyed on the larger scale of 4 inches =1 mile. The survey of the Hooghly River, with a strip on each bank varying from a quarter of a mile to one mile and upwards, was commenced during the year. A reliable survey of the river has long been wanted, and it is now being carried on *pari passu* with a survey of the bed of the river now in progress under the orders of the Port Commissioners. The survey is to be conducted on two scales. From Kanchrapara, a station on the Eastern Bengal Railway, down to Atchipore it is to be on the scale of 16 inches to the mile, and from Atchipore to the sea on the 6-inch scale.

5. The Government of India notices with satisfaction that the triangulation has in each case been kept well in advance of the topographical work.

6. There were two *mauzawar* or village survey parties employed during the year under review—one in the Punjab and the other in Bombay. The Punjab party was engaged on the 4-inch scale of—

(*a*) Pargana Leiah, in Dera Ismail Khan.

(*b*) Pargana Sinanwan (Thal portion) in Muzaffargarh.

(*c*) Kala Chitta Pahar, in Rawalpindi (for the use of the Forest Department).

The total area surveyed was 1,864 square miles.

The Bombay party was engaged in the Thana (Konkan) District. The larger scale of 4 inches = 1 mile was adopted instead of the 2-inch scale, in accordance with a letter from the Home Department, No. 830F., dated the 20th September 1881, on the ground that maps on the lesser scale are insufficient for the administration of the forests which cover large tracts in the Thana District. It was, however, agreed that the Forest Department of Bombay should be charged with the additional cost of the more expensive survey on the larger scale.

7. Cadastral or field surveys were conducted by six parties—two in the North-Western Provinces, three in British Burma, and one in Sylhet.

The Mirzapur party surveyed 750 square miles on the scale of 16 inches to the mile. With a view to effect a large reduction in the usual cost of preparing the record of rights, the experiment of allowing the surveyors to write

up the *khasra* (*i.e.*, the return in which the particulars about each field are entered) at the time of the survey of the fields, was undertaken by Colonel Anderson at the request of the Board of Revenue. The results of the experiment, so far as it has gone, is believed to be highly satisfactory. The second North-Western Provinces party completed the Ghazipur District, and continued work in Ballia during the season.

8. The three Burma parties were employed respectively in Hanthawaddy, Bassein, and Tharrawaddy. The outturn of work in this Province has been very satisfactory, the total area surveyed being 3,513 square miles. The Government of India regrets to observe the unfavourable opinion expressed as to the merits of Burman surveyors. Though their work is good in quality, they are said to be very inferior to the Hindustani surveyors in rapidity of execution, and to work in a half-hearted way with a sole eye to employment in some other Department.

9. In Assam a small party, specially organised, has been engaged on the cadastral survey of selected villages in three parts of the Sylhet District, to test the accuracy of the *mahalwar* maps of the district which were prepared by the civil authorities in 1862; sixteen photozincographed sheets of the work done by this party have been submitted to the Chief Commissioner of Assam, and the Government of India awaits the final report on the result of the testing.

10. The future employment of the cadastral parties which have been organised in the North-Western Provinces and in Burma, with great trouble and expense, has for some time past been under the consideration of the Government of India. A programme is now being drawn up in communication with Local Governments which, it is expected, will meet the requirements of the latter for the next ten years, and provide the Department with ample work for that period.

11. The survey of the Darjeeling District was undertaken in consequence of certain errors in the old maps having been brought to notice by the late Captain Harman's party when it was surveying new boundary lines and re-laying old ones. This has eventually involved the re-survey of the whole of the Hill Tracts west of the Teesta river. It is interesting to notice, in connection with this survey, the discovery made by Captain Harman, that the mountain which has hitherto been pointed out as Mount Everest from the neighbourhood of Darjeeling, is not that mountain; the true Mount Everest being immediately to the left (or south) of the peak which generally passes for it. The Government of India regrets to learn the recent death, when on furlough, of Captain Harman, an officer of much ability and energy.

12. The sections under the head of *Geography, Tidal and Levelling Operations* and *Geodetic* are, as usual, very interesting. The Burma-Manipur boundary was surveyed by Major Badgley, the demarcation of which was undertaken by the Political Agent and Boundary Commissioner, Colonel Johnstone. Major Badgley took advantage of his return journey to complete as much as possible of the survey of the Manipur territory. No actual survey was executed in Afghanistan, but a great deal of progress has been made with the final mapping of the surveys which were made during the late war. The Native Surveyor, Ahmed Ali Khan, deserves credit for the work he has performed in Dardistan and on the Kishanganga watershed; and the accounts of the Trans-Himalayan explorations are very interesting, and reflect great credit on the several officers who undertook them.

13. The Government of India notices with pleasure that the tidal observations, in addition to their practical value for the requirements of navigation, are now furnishing information which is found to be of much scientific value. These observations have recently thrown light on the question of the degree of the rigidity of the earth, and the following extract from paragraph 227 of the Report shews the esteem in which the Indian tidal observations are held by the scientific world:—

"At the recent meeting of the British Association for the advancement of Science at Southampton, Mr. G. H. Darwin brought forward a 'numerical estimate of the rigidity of the earth,' which gives evidence of a tidal yielding of the earth's mass, and further indicates

that the effective rigidity of the whole earth is about equal to that of steel. But it is only recently that there has been a sufficient accumulation of tidal observations, properly reduced by harmonic analysis, to test Sir William Thomson's theory (that the universal existence of oceanic tides of considerable height is a proof that the earth, as a whole, possesses a high degree of rigidity, and that the previously received geological hypothesis of a fluid interior is untenable); and Mr. Darwin points out that the great advances in knowledge that have now been made are principally due to the adoption of systematic tidal observations at a great number of stations by the Indian Government."

14. With regard to the spirit levelling operations, the revision of the Western Ghât section of the line of levels from Madras to Bombay was undertaken with a view to ascertaining whether any accidental error had been made in levelling up the steep ascent of the Ghâts, that would account for the discrepancy of 3 feet which had been met with at Madras on comparing the value of the mean sea determined from the local tidal observations with the value given of the spirit levelling from Bombay. The revision, however, gave practically identical results with the first operations.

15. The second part of the Report deals with the operations of the several Head-quarters Offices of the Department. The two Offices of the Surveyor General and the Deputy Surveyor General (Revenue Survey Office) at Calcutta are now accommodated in the new building recently constructed, which has been well designed and admirably built. It has also been found to be commodious and airy. The Government of India notices with satisfaction the progress that has been made towards completing a series of outline maps of India on scales of 1 inch to 64 miles, 80 miles and 96 miles. These maps are always in great demand to illustrate official reports. A new map of Bengal, Behar and Orissa, with hills, on the scale of 1 inch=16 miles was printed; and at the request of the Quarter Master General in India, a map of Lower Egypt was drawn and published for the use of the troops proceeding to Egypt. Maps of the Suez Canal, Cairo and Alexandria were also printed. All these were in great demand, and large numbers were bought by the public. The number of cadastral maps published during the year was 5,090. The experiments with the heliogravure process, which Major Waterhouse conducted in the Photographic Branch, seem to have been eminently successful. A full account of the process, which is practically a cheap substitute for copper engraving, is given at page 99 of the Report, and the print which appears as a frontispiece is a good example of the results attained.

16. The cost of cadastral surveys has been reduced even lower than what it was last year. In the North-Western Provinces it was Rs. 138-13-3 per square mile (Rs. 0-3-6 per acre) as compared with Rs. 159-4-11 per square mile (Re. 0-4-0 per acre) in 1880-81. In British Burma, too, the general rate for the year was lower than that of last year, *viz.*, Rs. 232-4-9 per square mile (Re. 0-5-0 per acre) against Rs. 250-8-7 per square mile (Re. 0-6-3 per acre). The topographical surveys worked at rates similar to those of last year. These results are very satisfactory, and tend to confirm the opinion of the Department that its field survey work will compare favourably in cost, as it unquestionably does in accuracy, with the surveys executed by patwaris and other unprofessional agencies. It now rests with the Survey Department to maintain, and, if possible, improve, the very creditable standard of economy attained in cadastral surveys during the year under report.

17. The ability with which General Walker administered the Department during 1881-82 is again acknowledged by the Government of India.

ORDER.—Ordered, that copies of the Resolution be forwarded to the Surveyor General of India, to the Local Governments and Administrations noted in the margin, and to the Foreign and Military Departments.

Madras.	Punjab.
Bombay.	Central Provinces.
Bengal.	British Burma.
North-Western Provinces and Oudh.	Assam.
	Coorg.

(True Extract.)

T. W. HOLDERNESS,

Offg. Secretary to the Government of India.

1883.

GOVERNMENT OF INDIA.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEYS.

RESOLUTION.

Circular No. 40S.

Dated Simla, the 1st June 1883.

SUBJECT.

Reviews the General Report on the operations of the Survey of India during the year 1881-82.

Govt. C. B. Press, Simla.—No. 177, R. & A. D.—31-5-83.—600.

GENERAL REPORT

ON THE

Operations of the Survey of India Department,

ADMINISTERED UNDER THE GOVERNMENT OF INDIA

DURING

1882-83.

LIBRARY OF THE BOMBAY BRANCH OF THE ROYAL ASIATIC SOCIETY

PREPARED UNDER THE DIRECTION
OF
COLONEL G. C. DE PRÉE, S.C.
Offg. Surveyor-General of India.

Calcutta:
PRINTED AT THE BENGAL SECRETARIAT PRESS.
1884.

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GENERAL REPORT

ON THE

Operations of the Survey of India

DURING THE SURVEY YEAR

1882-83.

INTRODUCTORY.

THE general direction of the Survey of India Department continued in the hands of Lieutenant-General Walker, C.B., R.E., F.R.S., &c., Surveyor-General of India, until February 1883, when it passed to those of Colonel G. C. DePrée, B.S.C., who was appointed to officiate in his room on his availing himself of special furlough to England, subsequently extended to 12 months. General Walker also directly superintended the two surveys of the Trigonometrical and Topographical Branches until the end of 1882, when he retained the former, but transferred the latter to Colonel DePrée, who was appointed a Deputy Surveyor-General from the 1st January 1883. The latter officer has continued to supervise the Topographical Branch conjointly with the direction of the department. On the departure of General Walker, Mr. J. B. N. Hennessey, M.A., F.R.S., who has been so long connected with the Trigonometrical Branch, assumed its superintendence, having been appointed to officiate as Deputy Surveyor-General. The superintendence of the Revenue Branch has continued in the hands of Colonel J. Sconce, B.S.C., Deputy Surveyor-General. Under the orders of the Government of India the Officiating Surveyor-General with his personal office proceeded to Simla during the usual period instead of resorting to Mussoorie as of late.

2. The principal operations carried on during the year, commencing from 1st October 1882 and ending 30th September 1883, are as follows:—

Statement of Survey Operations and Parties.

Number in this Report.	Nature and *locale* of operations.	Names of Executive Officers.	Designations of survey parties.	REMARKS.
	Triangulation.			
I	Ganjam and Orissa coast...	J. McGill, Esq.	Secondary Triangulation Party.	
II	Burma	Major J. B. McCullagh ...	Burma ditto.	
	Topography.			
III	Central India	Major C. Strahan, R.E. ...	No. 1 Topographical Survey.	1-inch and ½ inch scales for reproduction.
IV	Khandesh	„ T. T. Carter, R.E. ...	No. 2 Topographical Survey.	2-inch scale for reproduction and reduction to 1-inch.
V	Mirzapur district, N.-W. P.	„ J. R. Wilmer, S.C. ...	No. 5 Topographical Survey.	2-inch scale for reproduction.
VI	Sylhet district, Assam ...	Lieut.-Colonel R. G. Woodthorpe, R.E.	No. 6 Topographical Survey.	2-inch and ½-inch scale for reproduction.
VII	Burma	Mr. H. Horst	No. 7 Topographical Survey.	4-inch scale for reproduction.
VIII	Mysore	Lieut.-Colonel H. R. Thuillier, R.E.	No. 8 Topographical Survey.	1-inch scale for reproduction.
IX	Kohat district, Punjab ...	Major T. H. Holdich, R.E....	Kohat Topographical Survey.	4-inch scale for reproduction.
X	Guzerat	Colonel C. T. Haig, R.E. ...	Guzerat Survey ...	2-inch scale for reproduction and reduction to 1 inch.

Number in this Report.	Nature and *locale* of operations.	Names of Executive Officers.	Designations of survey parties.	Remarks.
	Topography—concluded.			
XI	Cutch	Lieut.-Colonel A. Pullan, S.C.	Kattywar and Cutch Survey.	2-inch scale for reduction to 1-inch.
XII	Bulandshahr and Aligarh districts, N.-W. P.	Mr. E. T. S. Johnson ... Mr. J. O. N. James ...	No. 3 Revenue Branch.	2-inch scale for reproduction and for reduction to 1-inch scale.
XIII	South Deccan	Major D. C. Andrew, Captain J. R. Hobday, and Lieut. F. B. Longe, R.E.	No. 11 Revenue Branch.	2-inch scale for reproduction and reduction to 1-inch scale.
XIV	Hooghly River	Major S. H. Cowan, S.C., and Mr. E. C. Barrett.	No. 6 Revenue Branch.	Partly on 16-inch scale and partly on 6-inch for reproduction to same scales.
XV	Baluchistan	Major R. Beavan, S.C. ...	Baluchistan Survey	1-inch and ½-inch scales for reproduction.
	Mouzawar or Village Surveys.			
XVI	Hissar district	Lieut.-Colonel D. Macdonald, S.C.	No. 1 Revenue Branch.	2-inch scale for reproduction and reduction to 1-inch scale.
XVII	Thana district	Major J. Hill, R.E. ...	No. 10 Revenue Branch.	4-inch scale for reproduction and reduction to 1-inch scale.
	Cadastral or Field Survey.			
XVIII	Ballia and Benares districts.	Major W. Barron, S.C. ...	No. 4 Revenue Survey.	16-inch scale for reproduction to same scale and for reduction to 1 inch scale.
XIX	Mirzapur and Terai districts.	Colonel F. C. Anderson, S.C.	No. 5 Revenue Survey	
XX	Hanthawaddy and Pegu districts.	Major J. R. McCullagh, R.E.	No. 2 Revenue Survey.	16-inch scale for reproduction to same scale, also for reduction to 2-inch and 1-inch scales.
XXI	Bassein and Henzada districts.	„ W. H. Wilkins, S.C., and Major H. S. Hutchinson.	No. 8 Revenue Survey.	
XXII	Tharrawaddy and Prome districts.	Mr. H. B. Talbot	No. 7 Revenue Survey.	
	Miscellaneous.			
XXIII	Darjeeling district and Nepal boundary.	Captain J. R. Harman, R.E., and Lieut.-Colonel H. C. B. Tanner, S.C.	Darjeeling Survey ...	Various scales.
XXIV	Geographical— 1. North Afghanistan, &c. 2. Great Tibet. 3. Dardistan.			
	Tidal and Leveling Operations.			
XXV	Tidal operations	Major M. W. Rogers, R.E., and Major A. W. Baird, R.E.	Tidal and leveling party.	
XXVI	Tidal disturbances due to volcanic eruptions.			
XXVII	Spirit leveling operations			
	Geodetic.			
XXVIII	Electro-telegraphic determinations of longitude.	Major W. J. Heaviside ...	Nos. 1 and 2 Astronomical parties.	

TRIANGULATION.

3. The preceding Report of the Survey of India, viz. that of 1881-82, afforded a concise description of the principal triangulations of the Great Trigonometrical Survey from its inception in 1800 by Major Lambton till its conclusion in 1882 under the direction and superintendence of Lieutenant-General J. T. Walker, C.B., R.E., F.R.S., &c. It was explained that certain series of secondary class were still required within India proper, and one field party has been engaged on the coast of Ganjam and Cuttack with a view to determine fixed points, beacons, and other marks for the use of the Marine Survey Department. The very important Secondary Series for the object of joining Singapore with India by means of an extension of the Eastern Frontier Series, now in abeyance since the measurement of a verificatory base-line at Mergui, has been brought to prominent notice of late owing to the proposals of the Government of the Straits Settlements to commence a Revenue Survey of the three settlements of Penang *cum* Wellesley, Malacca, and Singapore; in the prosecution

BAY OF BENGAL
INDEX CHART
TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA
CEYLON

of which assistance is solicited from the Survey of India. It is to be hoped that this important work may be continued when favourable conditions arise.

4. The other operations of a special nature have been prosecuted by the field parties, in continuation of the work of the previous year, in the case of the two Astronomical Parties working in concert on the electro-telegraphic longitude operations in the determination of differences of longitude, or time, between observatories, terminating arcs extending from Akyab to Central India: and again the Tidal and Leveling Party has continued its automatic registrations at all its observatories, and resulting investigations in recess quarters. The sanction of the Government of India has now been given to defray the expense of erecting two observatories at Colombo and Galle, the Government of Ceylon having declined the obligation, and this will complete the project for the establishment of a chain of these self-recording guages at all the prominent positions on the coast of India. It will be seen further on that records of extreme interest were obtained at the various observatories, of tidal disturbances having their origin in the great volcanic convulsion at the island of Krakatoa.

TOPOGRAPHY.

5. The regular topographical operations have been continued on the lines of previous seasons, with the following exceptions:—the Gwalior and Central India Party took over the survey of the remainder of the area hitherto assigned to the Rajputana Party, and assumed the name of the Central India and Rajputana Survey. The established Rajputana Party at the same time was transferred to British Burma and called the Burma Topographical Survey, and its sphere of operations changed from mapping the sandy desert to the minute measurements of a most difficult and intricate forest country.

6. The Khandesh Party completed the area remaining for survey in the Bombay Native States, and moved up into the ground of the Bhopal and Malwa Party, which was transferred to the district of Mirzapur with the object of surveying the hilly tracts on the extreme south of the district, and of supplementing the Cadastral Survey hitherto carried on by one of the parties of the Revenue Branch. The party so long connected with the North-east Frontier of Assam undertook the survey of certain hilly portions of South Sylhet, such as are not likely to come under the operations of a future Cadastral Survey, and completed the topographical delineation of the province. Half the party will be employed in 1883-84 on a survey of the unknown region south-east of Sadiya in Assam, between the Brahmaputra and the Patkoi range. Subsequent events, however, diverted the small party to the Aka country. The other half of the party has been moved to undertake a survey of the South Andaman Island—a work involving novel and peculiar conditions. The Kohat Party completed the survey of that district, and its name has now ceased to exist; the personnel having been transferred, including the energetic officer who has superintended its operations from the commencement, to the Baluchistan Topographical Party.

7. During the past season every opportunity has been taken to increase our knowledge of the countries beyond the British Frontier by employing the regular surveyors—European and Native—on such surveying expeditions as were compatible with due precautions for their safety, as well as by extending the system hitherto peculiar to the Trigonometrical Branch, of employing native explorers, who, in disguise, penetrate into otherwise inaccessible parts. This trans-frontier system had been commenced by the Kohat Party in a previous season, and was extensively carried on during the season under report. More detailed accounts will be found in section IX. In this way it is intended to gradually compile a map shewing the whole trans-frontier of Western India, from Peshawar to Baluchistan. An expedition to the Takht-i-Suliman is under contemplation, from which it is expected that valuable knowledge of the country between Ghazni and our frontier will be obtained; meanwhile, also the regular survey of Baluchistan will be pushed on as vigorously as possible, but there will be a limit to rapid progress in the difficulty of protecting more than a certain number of detached camps in that somewhat inhospitable tract. A demand will be complied with for the services of two special officers to accompany the progress of the Agent of the Governor-General through South-

Western Baluchistan to the sea, by which a large accession to our geographical knowledge may be anticipated.

8. The survey of the river Hooghly, from Saugor Island Light-house on the South to Baranagar, including a strip of the most valuable ground extending for about half a mile outwards from each bank, was completed, and the map has been supplemented by the soundings and river details measured by the officers of the Marine Survey. The No. 6 Revenue Party has now been moved to the Kámrup district, with a view to commence the new Cadastral Survey of Assam. The Topographical Survey of the Aligarh and adjacent districts was continued, and the No. 3 Revenue Party engaged thereon has now been broken up into detachments for effecting a Cadastral Survey of the Dehra-Dun, for commencing the Cadastral Survey of the Central Provinces and for the traverse survey of Ajmere, while a fourth detachment has continued to operate in the district of Aligarh.

9. In the parties of the Trigonometrical Branch no change took place beyond the Darjeeling Party effecting the completion of Sikkim; the undertaking of a small survey in the Daling Hills; and after completing the survey of the British-Nepal Frontier between the Kosi and Gandak the surveyors will be called upon to permanently define the line with ditch and pillars.

10. The general out-turn of topography executed during the year in the course of the operations described in sections III to VI, VIII to XV, XVII and XIX of this report, excluding Forest Surveys, has been as follows:—

7,384	square miles	surveyed on the	½-inch scale.
7,989	[redacted]	,,	1 ,,
7,855		,,	2 ,,
729	,,	,,	4 ,,
145	,,	,,	6-inch scale and larger.

MOUZAWAR, RIVERAIN, AND FOREST SURVEYS.

11. The survey of district Hissar commenced during the year, and designed, in the first instance, to be only a Topographical Survey, partakes of almost all the characteristics of a Mouzawar Survey; village boundaries being traversed and traverse tables constructed both for the purpose of projecting accurate boundary maps as well as to provide for an accurate calculation of total village areas. The survey in part only differs from an ordinary mouzawar in two particulars, viz. that it does not furnish detail areas as a check on Settlement Survey areas, and that it is plotted on the 2-inch scale instead of the 4-inch scale. In one particular, however, the survey is more elaborate than an ordinary Mouzawar Survey, in so much that it has determined the co-ordinate distances of permanent marks laid down net-wise at half mile intervals over the interiors of the village lands and is intended to furnish a basis for a subsequent Settlement Survey of the fields.

12. The Riverain Surveys on the 4-inch scale along the Jumna and Ganges rivers have been carried on, as formerly, in connection with the 2-inch Topographical Survey of the Gangetic Dooab; that along the Jumna river having been completed on its being brought down to the point where the river ceases to be the boundary between the North-West Provinces and the Punjab. The Riverain Survey commenced during the previous season on the Ganges river in connection with the Cadastral Survey of district Ghazipore has been continued along the Ganges and Gogra rivers for the village lands of districts Shahabad and Sarun, lying opposite to district Ballia, and has been carried on down to the junction of the united Ganges and Gogra rivers with the Sone river.

13. The survey party in the Kon-kan has continued to survey the Thana district on the scale of 4-inches to the mile for forest purposes, and has shewn the boundaries of the lands reserved for forests within villages as well as the boundaries of the villages themselves.

14. In Guzerat, the survey of the Dangs forest, commenced six seasons ago, was completed during the season under report.

15. In Burma, the expense of measuring up the intricate minor features to be found in the forest of the Pegu Yoma became so great that a modified system is to be introduced, the principle of which lies in an extremely accurate measurement of main features on which numerous permanent marks are left standing, from which at any future time it will be feasible to supplement the survey for any special purposes.

16. The areas of all these operations are:—

	Square miles.
Mouzawar	1,661
(Hissar District 2-inch survey.)	
Riverain	634
Forest	839

CADASTRAL SURVEYS.

17. In the North-West Provinces, the Cadastral Survey of the parts of district Mirzapur, where a Cadastral Survey is required, has been completed, and the party hitherto working in that district has prepared ground by traversing the village boundaries for commencing a Cadastral Survey of district Gorakhpur during the following season. This party has also continued the experimental measure initiated last season of writing the village *khasras* concurrently with the survey. The cadastral survey party which was working during the previous season in district Ballia has completed (with the exception of one detached village) the Cadastral Survey of that district, and has taken up the Cadastral Survey of district Benares. In Benares, this party, following the lead of the Mirzapur party, has undertaken the writing of the *khasras* as well as the survey of the fields, but has adopted a system of *khasras* and *jamabundi* writing of its own, worked out by the joint co-operation of Mr. F. W. Porter (Settlement Officer), and Major W. Barron, which differs in several very important aspects from the system followed in Mirzapur. The Mirzapur system provides for the *khasra*-writing only to be done during the season of survey, and for the final work of settlement attestation to be done during the following season; whereas, under the Benares system, both settlement and survey staffs take the field together, and provision is made for the completion of all the village papers within 12 months from the commencement of operations. His Honor the Lieutenant-Governor of the North-West Provinces conducted a personal inquiry at Benares during the field season with regard to the merits of the two systems, and ordered the final adoption of the Benares system.

18. During the recess, Major Barron has drawn up a very comprehensive hand-book of instructions for the guidance of survey parties engaged on the combined operations of survey and settlement in the North-West Provinces, and including directions for survey procedure as well as for *khasra* and *jamabundi* writing. The book is a very valuable one for the purpose for which it is intended, and will also serve as a basis for similar instructions to be framed for other provinces, according to local variations of tenures and rights of occupancy.

19. In British Burma, cadastral operations have been carried on in districts Hanthawaddy, Pegu, Bassein, Henzada, Tharrawaddy, and Prome; all the cadastral work required in Hanthawaddy and Tharrawaddy has now been completed, but large tracts in both districts remain for Topographical Survey.

20. The Hanthawaddy party has again sent a detachment to Arakan to carry on the demarcation work in connection with the previous surveys of the waste-land grants. This detachment was also required to make a survey of the Myin-bin oil field near Khyoukh-pyo on the Island of Ramree. Another detachment was sent out from this party to survey a portion of the Nat-ya-doung hill in the Tavoy district.

21. The areas surveyed cadastrally are:—

	Square miles.
North-Western Provinces	1,252
British Burma	2,035

GEOGRAPHICAL EXPLORATION AND RECONNAISSANCE.

GREAT TIBET.

22. The concise account of this remarkable exploration, carried on by A— K— in Mongolia and Great Tibet, contained in paragraphs 199 to 203 of the last Report of the Survey of India, cannot be amplified at this time. The observations are so numerous and so complete, and the work of compiling the mass of information consisting of angles, line, and geographical materials, contained in the field book written in a strange vernacular, is so laborious, that the details are not now in a state for publication, and a further delay of a few weeks must occur before they can be made known. The map showing the explorer's geographical discoveries is, however, complete, and is attached to this volume. It must suffice to say at this time, that the investigation of all the explorer's materials has shown the extraordinary excellence, minuteness, and accuracy of his observations, and notes taken under every circumstance of difficulty and danger. The vast tract of country traversed has now been brought under notice for the first time. The Russian traveller Prejevalsky has lately penetrated the Lob Nur lake, but the route of this explorer lies mainly on the south of his route and over hitherto virgin country. Besides the determination of the Sanpo river as the main affluent of the Brahmaputra, other most interesting problems relating to the course of the great rivers flowing into the Irrawaddy, the Salween, and the Yangtse Kiang have been advanced a stage by the travels of this explorer. Under these circumstances the 1st class medal of the Geographical Society of Italy, placed by the International Congress held at Venice in 1881 at the disposal of the Surveyor-General of India for presentation to the most meritorious explorer, has been adjudged to A— K—.

SURVEYS IN DARDISTAN.

23. The Native surveyor, Ahmad Ali, who was employed under the immediate orders of Mr. Hennessey, as detailed in section XXVI of the last report in surveying or rather sketching the Dardistan country lying round Chilas, has in the year under review further prosecuted this arduous work. As, owing to the hostility of the inhabitants, it is impossible for a surveyor to enter the country, it becomes necessary to attempt its delineation from the surrounding watersheds. As these vary in height from 15,000 feet upwards, a large amount of steady perseverance is necessary to enable the surveyor to surmount the many failures which are inevitable in attempting to work at such high altitudes.

24. Ahmad Ali has on the whole succeeded well. First ascending the watershed to the south-east of Chilas, and then crossing over into the Kunar valley, and reaching the southern watershed, he was enabled to sketch in all that was to be observed from those points.

25. This accomplished, the Native surveyor proceeded to Bunji fort in Kashmir territory, and thence succeeded in reaching various points on the watershed whence views of the Chilas country from the north-east were obtained. On the whole, the work must be considered very satisfactory and as filling up an awkward blank in our topographical knowledge of that country.

INSPECTION.

26. The Officiating Surveyor-General inspected the office of the Trigonometrical branch at Dehra, and that of the Hissar Party of the Revenue Branch, both during the recess; he also carefully studied the method of the Benares Cadastral Party as well as that of the Central India, and the Bhopal Topographical Parties in the field, during the year under review.

PART I.

THE OPERATIONS OF THE SEVERAL SURVEY PARTIES APPERTAINING TO THE THREE BRANCHES OF THE SURVEY DEPARTMENT.

TRIANGULATION.

I.—THE SECONDARY TRIANGULATION PARTY.

27. After the completion in 1881-82 of the principal series of triangles known as the Eastern Frontier Series, terminating about 120 miles south of Mergui (Burma), where a base-line was measured, a portion of the native establishment was absorbed, in accordance with the sanction of the Government, to form a party for purposes of secondary triangulation required in various localities, and in the first instance this party was employed to triangulate along the east coast, chiefly to set up beacons, and fix them as well as all other permanent conspicuous objects for the use of the Marine Surveys, &c.

Personnel.

J. McGill, Esq., Deputy Superintendent, 4th grade.

Mr. C. D. Potter, Assistant Surveyor, 1st grade.

28. The series of secondary triangles executed in the season runs along the east coast in the districts of Ganjam and Pooree, from the vicinity of Ichápur in the former district, to the town of Pooree so well known as the seat of Jagannáth's temple and a place of pilgrimage: it traverses a tract of country, generally well populated and prosperous, including sea ports and large towns, yet subject to malarious influences, so that the party suffered a good deal in health, and otherwise experienced some difficulties occasioned by the presence of creeks and the Chilka lake, in the line of their operations.

29. The length of the series executed was 97 miles: six beacons were specially erected on suitable sites for the use of the Marine Department, and in addition 115 permanent and conspicuous objects were also fixed: several of the latter will serve as beacons. All the stations were well and permanently marked, and placed under care of the local officials, so that future survey operations and especially those of the Marine Department can obtain points for reference readily and with certainty.

30. The field operations were all brought up to date during the recess, and charts of the work will shortly be published.*

31. Besides the secondary series of triangles reported on in the foregoing, the series to Singapore has also already been sanctioned by Government as mentioned in the Administrative Report for 1881-82. No action, however, has been taken on the work from want of officers and funds.

II.—THE SECONDARY TRIANGULATION IN BURMA.

32. These operations were last reported on in 1880-81 when, under the direction of Captain J. Hill, R.E., sub-surveyor Moung Shoay Gyoke, a native of Burma, was employed on them. In 1881-82 the Burma party was one of the three parties engaged on the measurement of the Mergui base-line and was therefore not reported on by itself. Subsequently, in November 1882, the party consisting of the sub-surveyor and a small native establishment, was placed under the directions of Major J. R. McCullagh, R.E., in charge Pegu and

Personnel.

Sub-surveyor Moung Shoay Gyoke.

* Mr. McGill reports of Mr. Potter:—"Notwithstanding the sickness in his camp and the difficult nature of the ground, he steadily kept to his work. * * I consider him a most efficient and zealous assistant."

Shoaygeen Districts Survey (Revenue Branch) who undertook to direct its operations in addition to his own duties. The sub-surveyor unfortunately experienced delay, and on arriving at his northern stations he unexpectedly found, so early as January, the view into Upper Burma, where he was to fix all visible points, greatly obscured by smoke from forest fires and dense haze. He, however, succeeded in taking observations from four stations; besides this duty, he was also primarily to perform the important work of protecting the stations of the series: in all, he visited 31 stations, and covered in, where practicable, 28 of them in the manner required for their protection. He also transferred them, as is necessary, to the care of the local officers.

33. Notwithstanding that Major McCullagh's time was so fully occupied by his own survey operations, he continued to direct the recess work of the Burma Party to the extent of preparing the preliminary transfer documents and disposing of them suitably; the reductions of the observations were unavoidably not taken up, especially as Moung Shoay Gyoke was on other duty until 1st October, and Major McCullagh's field operations made direction of the reductions, impracticable.

34. Moung Shoay Gyoke accordingly joined the Trigonometrical Branch Survey Office at Dehra-Dun on 8th November 1883, when the party was placed under charge of Mr. C. Wood, Surveyor, 1st grade, with instructions to bring up the computation, return the instruments, &c., into store, complete the transfer lists, arrange for payment and distribution of the establishment, and otherwise to dispose of all money matters. These duties were completed by the end of January, when the party was placed in abeyance.

35. The field work was unavoidably in confusion from the sub-surveyor's difficulty in identifying his objects; but eventually Mr. Wood succeeded in extricating and determining 15 points* of all of which he was also able to find the heights—six of these points are on the frontier, five others are on spurs of the Arakan Yoma and Pegu Yoma near the course of the Irrawaddy; two are on the ridge of the latter range; and the remaining two, and most northerly, are on an unknown range, said to be the Karenni mountains in about lat. 20°, long. 96½°, with heights of six to nearly seven thousand feet. These points will prove valuable in course of future operations.

III.—CENTRAL INDIA AND RAJPUTANA SURVEY (No. 1 TOPOGRAPHICAL PARTY).

36. As mentioned in last year's report, in consequence of the transfer of No. 7 Topographical Party to Burma, that part of Rajputana, which had been previously allotted to that Party, but which still remained unsurveyed, was made over to No. 1 Topographical Party for completion; the name of the survey being changed to "the Central India and Rajputana Survey." As it had been decided to complete the detail survey of those parts of Rajputana which had been previously triangulated by No. 7 Party, it became necessary to work in two divisions—one to complete the detail survey of Degree Sheet XVIII and the northern portion of Degree Sheet XIX of the Rajputana Survey, and the other the detail survey of portions of Degree Sheets XIV and XV of the Gwalior and Central India Survey.

Personnel.

Major C. Strahan, R.E., Deputy Superintendent, 2nd grade, in charge up to 30th April 1883.
Lieutenant the Hon'ble M. G. Talbot, R.E., Officiating Deputy Superintendent, 2nd grade, in charge from 1st May 1883.
Lieutenant R. A. Wahab, R.E., Officiating Assistant Superintendent, 1st grade, from 8th January to 14th September 1883.
Mr. W. J. Cornelius, Assistant Surveyor, 1st grade.
„ P. J. W. Doran, „ „ 1st „
„ C. T. Templeton „ „ 1st „ up to 28th April 1883.
„ A. Kitchen, Assistant Surveyor, 2nd grade.
„ G. P. Tate „ „ 3rd „
„ M. Gastaud „ „ 3rd „
„ P. Beechey „ „ 3rd „ from 25th April 1883.
Sub-Surveyor Abdul Guffar.
„ „ J. R. Harris.
„ „ Abdul Aziz,
and 4 others.

37. The triangulation, which was entirely carried on in the southern or Gwalior division of the survey, was entrusted to Mr. C. T. Templeton, and the detail survey to Lieutenant Wahab, Mr. J. Cornelius, and the other members

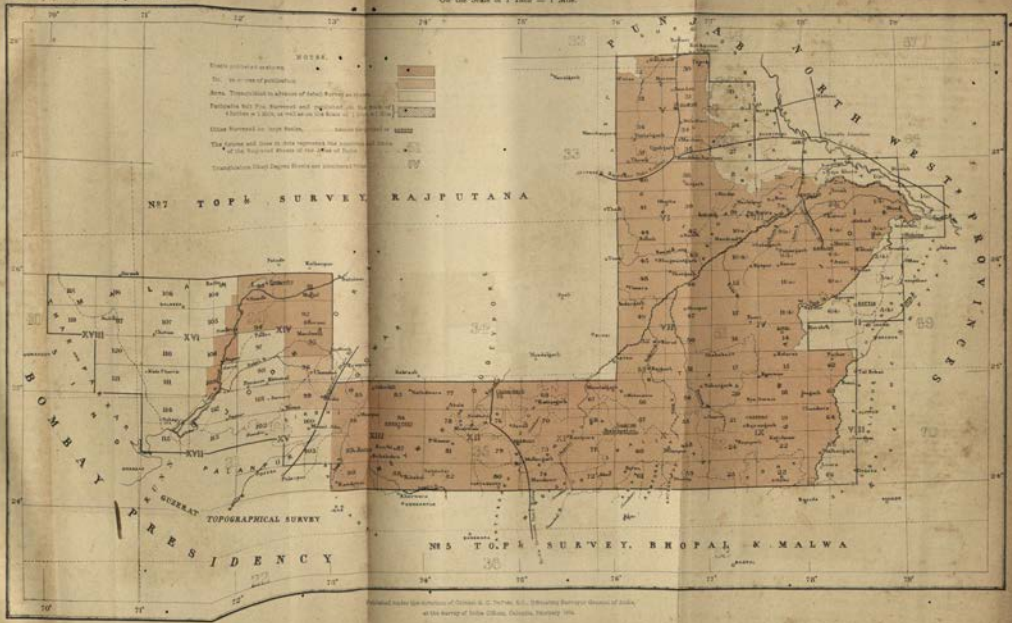
* Of those, the rays to the nine transfrontier points include an area of 11,000 square miles exterior to the station from which they were observed.

No. 1 PARTY.

INDEX TO THE SHEETS OF THE GWALIOR & CENTRAL INDIA TOPOGRAPHICAL SURVEY.

On the Scale of 1 Inch = 1 Mile.

To accompany Surveyor General's Report for 1882-83.

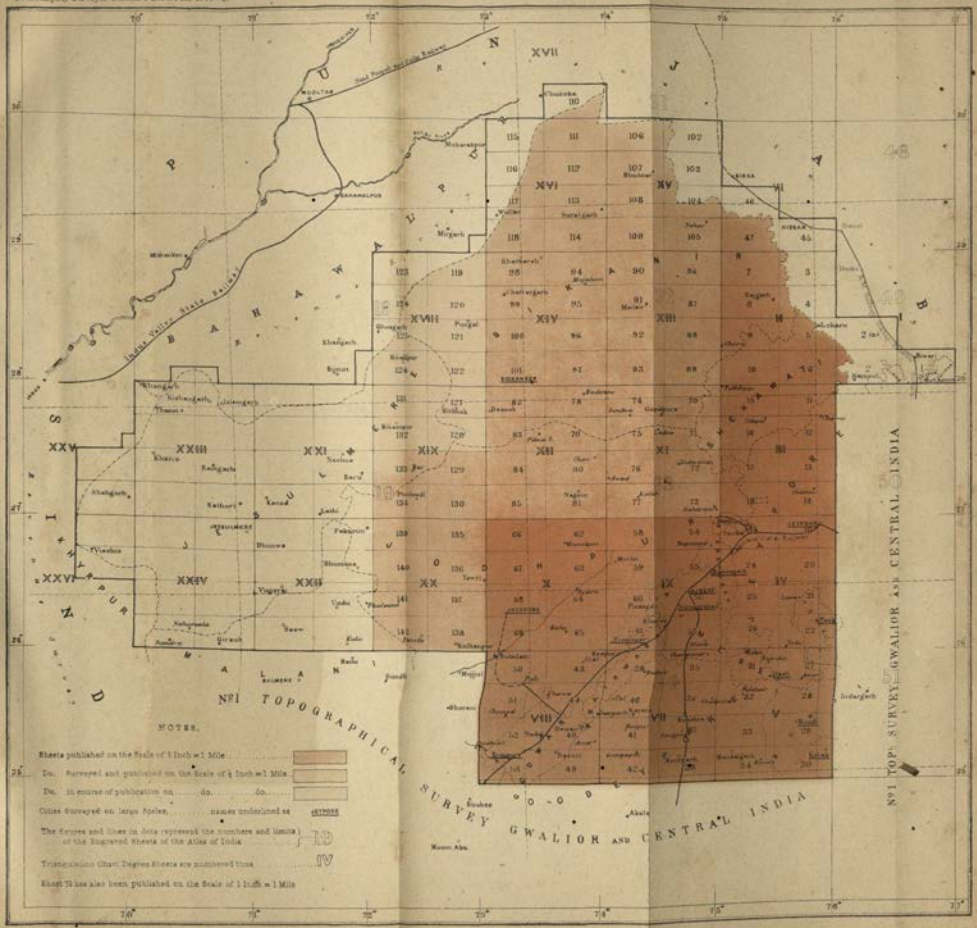


No. 7 PARTY.

INDEX TO THE SHEETS OF THE RAJPUTANA TOPOGRAPHICAL SURVEY,

On the Scales of 1 Inch = 1 Mile and ¼ Inch = 1 Mile.

To accompany Surveyor General's Report for 1882-83.



NOTES.

Sheets published on the Scale of 1 Inch = 1 Mile

Do. Surveyed and published on the Scale of ¼ Inch = 1 Mile

Do. in course of publication on do. do.

Cities surveyed on large Scales, names underlined as CITYSIDE

The figures and lines in dots represent the numbers and limits of the Engraved Sheets of the Atlas of India

Trigonometrical Chart. Degree Sheets are numbered thus IV

Sheet 78 has also been published on the Scale of 1 Inch = 1 Mile

Published under the direction of Colonel G. C. DePree, R.C., Officiating Surveyor General of India,
at the Survey of India Offices, Calcutta, February 1884.

No. 2 PARTY.

INDEX TO THE SHEETS OF THE KHANDESH & BOMBAY NATIVE STATES TOPOGRAPHICAL SURVEY.

On the Scales of 1 Inch = 1 Mile and 2 Inches = 1 Mile.

To accompany Surveyor General's Report for 1882-83.

NOTES.

Sheets published on the Scale of 1 Inch = 1 Mile .....

Do. in course of publication .....

Do. Surveyed on the Scale of 2 Inches = 1 Mile and published on the Scale of 1 Inch = 1 Mile. .....

Do. in course of publication .....

Area Triangulated and Traversed in advance of detail Survey .....

Cities Surveyed on large Scales, names underlined as DHULIA

The figures and lines in dots represent the numbers and limits of the Engraved Sheets of the Atlas of India. 36

Triangulation Chart Degree Sheets are numbered thus (V)

Published under the direction of Colonel G. C. DePrée, R.C., Officiating Surveyor General of India, at the Survey of India Offices, Calcutta, February 1883.

of the party who were employed in the country south-west of Erinpura, as well as in the desert on the west of Bickaneer. The results of the season's work, &c., &c., are an out-turn of completed survey of 846 square miles on the scale of 1 inch = 1 mile, and of 5,534 square miles on the scale of $\frac{1}{2}$ inch = 1 mile. This will admit of the publication of Standard Sheets 96 and 99 of the Gwalior and Central India Survey, and of half Degree Sheets XVIII north, XVIII south, XIX north, and XIX south, of the Rajputana Survey.

38. The country under survey in Rajputana was of the usual type met with in the Jodhpore and Bickaneer Deserts, and presented great difficulties to the surveyors on account of the scarcity of water and the dearth of supplies. An interesting account by Major Strahan of the little known sect of Bisnuis will be found in the Appendix.

39. During the course of the field season the Resident of the Eastern Rajputana States brought to notice the very incomplete state of the existing large scale map of the City and Environs of Jeypore. So many alterations and additions to buildings and enclosures have of late years taken place, in a great measure in consequence of the construction of the Rajputana Railway, which passes through that city, that a new and enlarged map is greatly required. Orders were therefore issued to the officer in charge No. 1 Topographical Party to undertake the triangulation necessary, to enable the detail survey to be taken in hand in the coming field season. With this view, Mr. Templeton, an experienced assistant, was deputed to commence the work. Unfortunately Mr. Templeton, while so employed, fell seriously ill, necessitating an immediate cessation of work and return to recess quarters; and he eventually succumbed to an attack of diphtheria at Saharanpore, on his way to Mussooree, on the 29th April. Mr. Templeton had been nearly 13 years in this Department. He was a very painstaking, steady, most trustworthy officer, and his loss to the Department is to be much regretted.

40. During the ensuing season the party will be employed on the survey of Standard Sheets 97, 100, and 103 of the Gwalior and Central India Survey, on the scale of 1 inch = 1 mile, and on the triangulation of the country of Bármer, adjacent to the Luni river. The triangulation for the re-survey of the City of Jeypore and its extension to Ambar, also the revision and extension of the Ajmere City Map will be resumed, and as much of their detail survey be undertaken as time will allow of.

41. Major Charles Strahan, who has for the last 16 years so ably held charge of this party, has now been transferred to the head-quarters of the Survey of India at Calcutta, to take charge of the Drawing and Engraving Offices. The charge of the party devolved at first, during the recess, on Lieutenant the Hon'ble M. G. Talbot, and subsequently on Major Beavan, transferred from the charge of the Baluchistan survey.*

IV.—KHANDESH AND BOMBAY NATIVE STATES SURVEY (No. 2 TOPOGRAPHICAL PARTY).

42. The survey of the portions of Khandesh and Násik allotted to this party, has been brought to a successful conclusion during the season under review, and a commencement has been made with the survey of that part of the Central India Agency which has been made over to this party for completion, situated on the west of Rutlam. Hence the designation has been changed to "The Bhopal and Malwa Survey."

Personnel.

Major T. T. Carter, R.E., Deputy Superintendent, 2nd grade, in charge.
Mr. J. A Barker, Assistant Surveyor, 1st grade.
" F. E. Wardo " " 1st " transferred to the Kohat Party from 1st June 1883.
Mr. G. Vanderbeck, Assistant Surveyor, 2nd grade.
" A. Bryson " " 3rd " rejoined from the half-pay list on the 15th May 1883.
Mr. C. George, Assistant Surveyor, 3rd grade.
Sub-Surveyor Sheik Omor.
" " F. Rozario.
" " Hyder Ali,
and 5 others.

43. The survey of the Khandesh and Bombay Native States was commenced in the year 1871, and comprises an area of 18,133 square miles, lying between the parallels of 20° and 22° 30′ north latitude and the meridians of 74° and 76° 30′ east longitude, and

* Major Strahan speaks very favourably of the services of the European assistants attached to this party, more especially of Mr. A. Kitchen. The native surveyors are, with one exception, also well reported on.

includes the whole of Khandesh, together with certain outlying villages of Khandesh and Násik situated in the territory of His Highness the Nizam, with the exception of a small portion of the Pimpalner taluka, west of the meridian of 74° east longitude.

44. Of the total area, about 10,532 square miles have been surveyed and published on the scale of 1″ = 1 mile, and the remainder, 7,601 square miles, surveyed on the scale of 2″ = 1 mile, but published on the 1″ scale. The portion surveyed on the 1″ scale comprises the rugged and hilly tracts lying between the Tapti and Nerbudda rivers, forming portion of the Satpura range and the tract of country lying above the ghâts of the Satmala hills; that surveyed on the 2″ scale consist of the alluvial valleys of the Tapti river and its tributaries where the country is rich and productive. In this tract the valleys are numerous, well cultivated, and connected by good roads; the country being moreover tapped by the Great Indian Peninsula Railway.

45. During the season under review, the total out-turn of work was 991 square miles of detail survey on the 2″ and 546 square miles on the 1″ scale. An area of 90 square miles was triangulated and 287 miles of traversing were completed, fixing 154 village tri-junctions. In addition, 600 square miles of the Bhopal and Malwa Survey, comprising Standard Sheet 64, were triangulated in advance of topography. It is estimated that it will take two seasons to complete the remaining portion of this survey.

46. During the year the amount of mapping published and made available to the public, covers an area of 1,550 square miles, comprising Standard Sheets 21, 23, 24, and 34.

The Standard Sheets which have been mapped during the season are 5 in number, viz. Nos. 36, 39, 40, 41, and 42. These have been drawn and are in course of publication.

47. During the ensuing field season it is expected to complete the triangulation of sheets 58 and 59 and the detail survey of sheet 54.*

V.—THE MIRZAPUR SURVEY (No. 5 TOPOGRAPHICAL PARTY).

48. As mentioned in last year's report on the survey operations, the bulk of this party was moved from the Central India Native States, in which it has been so long employed, to the British district of Mirzapur, the work allotted to it being the survey on the scale of 2″=1 mile of that portion of the district lying south of the Keymore range and the Sone river, consisting of the parganas of Agori, Singrauli, and Dudhi; this latter being also prepared by boundary-traversing, &c., for a future large-scale settlement survey.

Personnel.

Major J. R. Wilmar. Deputy Superintendent, 4th grade, in charge.
Mr. W. H. Patterson, Officiating Assistant Superintendent, 1st grade (from 1st February 1883).
Mr. C. F. Hamer, Surveyor, 4th grade
„ E. A. Wainwright, Assistant Surveyor, 1st grade.
Mr. H. T. Kitchen, Assistant Surveyor, 1st grade.
„ W. H. Lilley, ditto, 1st „
Sub-Surveyor Azim Khan.
Ditto Prem Raj,
and six others.

In addition to the abovementioned work, there will remain to be completed on the scale of 2″ = 1 mile, and partly on the 16-inch scale, by this party, several tracts of country in district Mirzapur, which, owing to their hilly and jungly nature, were not surveyed by the Revenue Survey Party lately working in that district.

49. The area of detail survey on the scale of 2″=1 mile completed in Mirzapur district was 214 square miles, in addition to which 41 miles of simple traversing and 120 miles of boundary survey were executed in pargana Dudhi.

50. That portion of the party which was not employed in Mirzapur district was despatched to its old ground in Central India, in order to complete Standard Sheet 49 of the Bhopal and Malwa Survey on the scale of 1″ = 1 mile. This they succeeded in doing, and in addition mapped one-third of the contiguous Sheet No. 52, the whole area surveyed covering 726 square miles.

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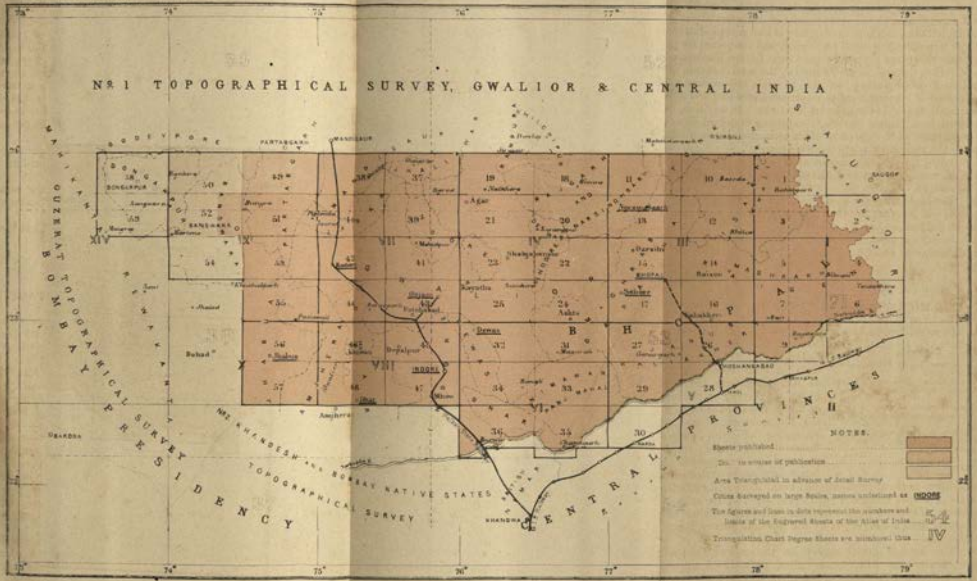
* Major Carter reports that "Messrs. Wyatt and Vanderbeck, and Sub-Surveyors, Sheik Omer, Mr. Rozario, Hyder Ali, and Sheik Mohidin deserve special mention."

No. 5 PARTY.

INDEX TO THE SHEETS OF THE BHOPAL & MALWA TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile.

To accompany Surveyor General's Report, 1882-83

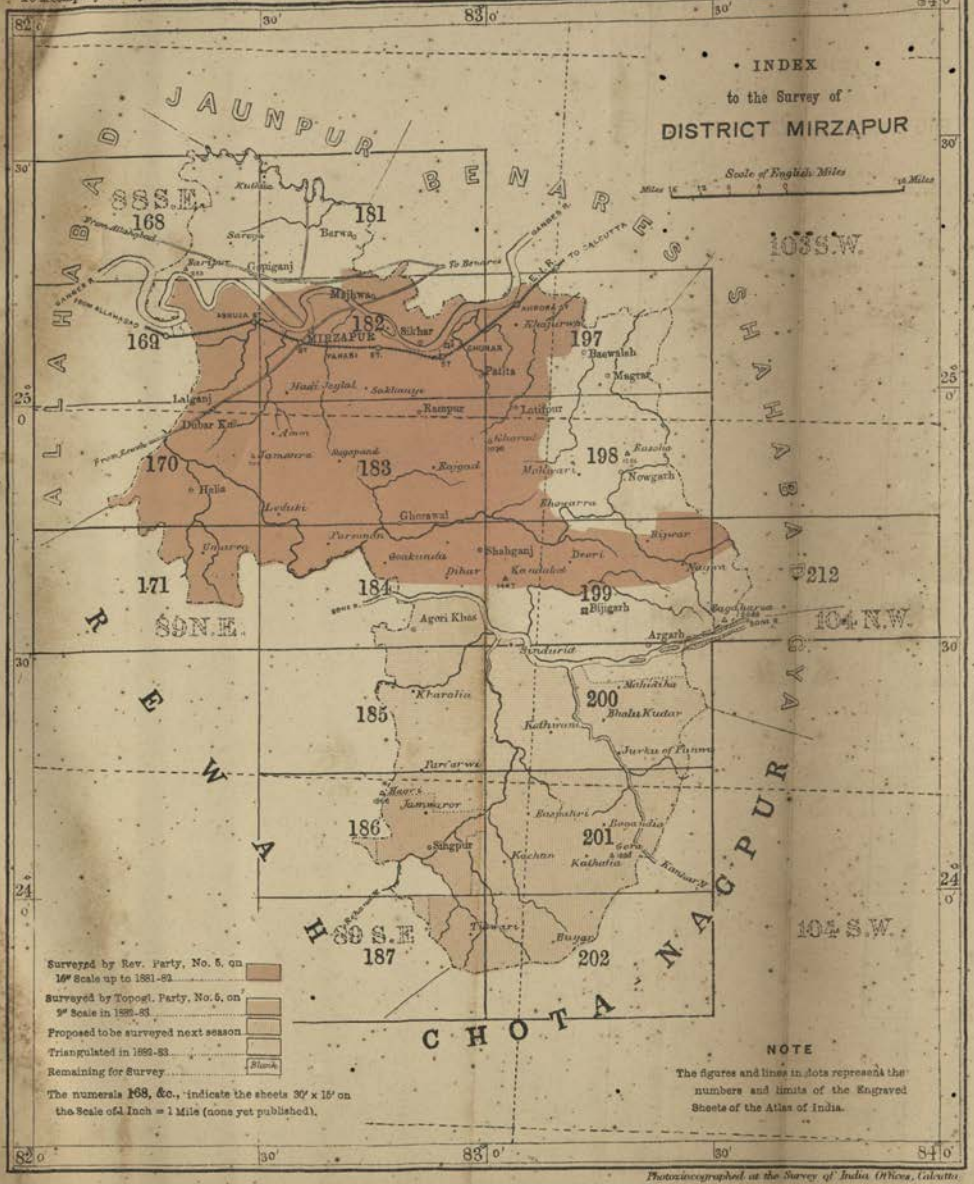

No. 1 TOPOGRAPHICAL SURVEY, GWALIOR & CENTRAL INDIA
GUZERAT TOPOGRAPHICAL SURVEY
BOMBAY PRESIDENCY
MEWAR, MALWA & BOMBAY NATIVE STATES TOPOGRAPHICAL SURVEY
CENTRAL PROVINCES
BERAR
NOTES.
Sheets published
Do. in course of publication
Area Triangulated in advance of detail Survey
Cities Surveyed on large Scales, names underlined as INDORE
The figures and lines in dots represent the numbers and limits of the Engraved Sheets of the Atlas of India 54
Triangulation Chart Degree Sheets are numbered thus IV

Published under the direction of Colonel G. C. DePrée, R.C., Officiating Surveyor General of India, at the Survey of India Office, Calcutta, February 1884.

No. 5 TOPOGL. PARTY.

N. W. PROVINCES SURVEY.

To accompany Surveyor General's Report for 1882-83.



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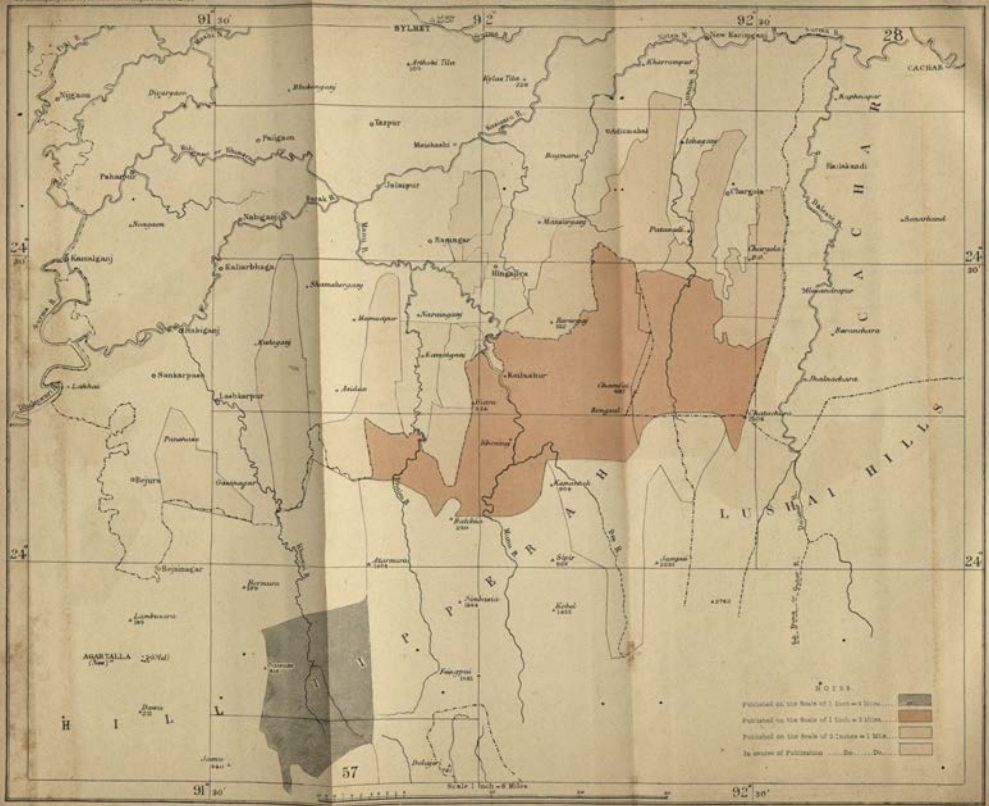
Published under the direction of Colonel G. C. DePrée, S.C., *Officiating Surveyor General of India.*

Survey of India Offices, Calcutta, December 1883.

To accompany Surveyor General's Report for 1882-83

INDEX TO THE SURVEY OF SOUTH SYLHET AND TIPPERAH HILLS.



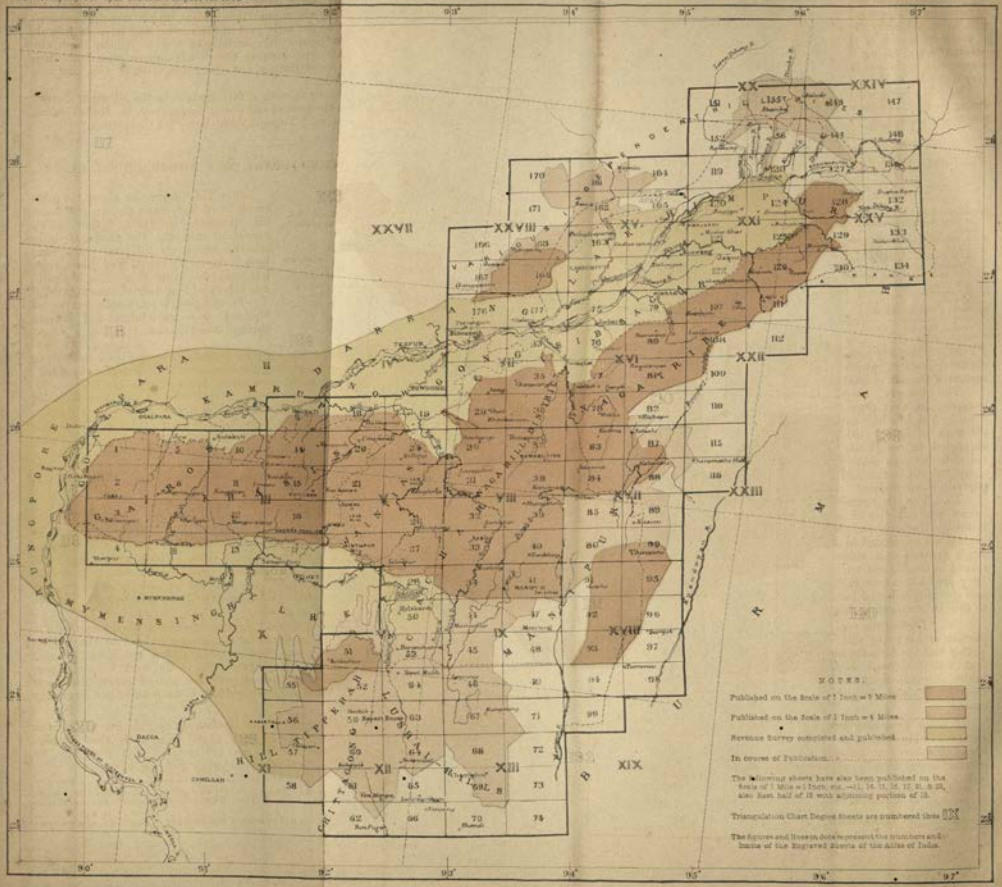
Published under the direction of Captain H. C. Jerram, R.E., Officiating Surveyor General of India at the Survey of India Offices, Calcutta, February 1884.

No. 6 PARTY.

INDEX TO THE SHEETS OF THE GARO, KHASI, AND NAGA HILLS AND NORTH EAST FRONTIER TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile, ½ Inch = 1 Mile, and ¼ Inch = 1 Mile.

To accompany Surveyor General's Report for 1882-83.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51. The ground under survey during the year, in district Mirzapur is by no means favourable to survey operations. It is a hilly, broken country, covered with forest, unhealthy during the early part of the season, and later on difficult of access by reason of the comparative scarcity of water. Under these circumstances, and taking into consideration the disadvantages attendant upon commencing operations in a new district, the out-turn of work of this party is very creditable to Major Wilmer.

52. The party will continue work at full strength in the Mirzapur district during the ensuing season, the ground remaining for survey in Malwa being now finally handed over to No. 2 Topographical Party for completion.*

VI.—NORTH-EAST FRONTIER SURVEY (No. 6 TOPOGRAPHICAL PARTY).

Personnel.

Lieutenant-Colonel R. G. Woodthorpe, R.E., Officiating Deputy Superintendent, 4th grade, in charge.
Mr. J. Peyton, Surveyor, 1st grade.
„ J. Ogle „ 3rd „
„ A. W. Chennell „ 4th „ (died, 5th October 1883).
„ F. R. McCay, Assistant Surveyor, 2nd grade.
„ J. Keating „ „ 2nd „
„ D. Campbell „ „ 3rd „
„ A. Ewing „ „ 3rd „
Sub-Surveyor Shah Nasiruddin.
Ditto Dalilurain.
Ditto Fida Ali,
and seven others.

53. This party, as stated in paragraph 58 of last year's Report, continued the operations in South Sylhet, which consist of mapping the tracts of hilly country which up till late years have been lying uncultivated, and which were left unmapped at the time when the revenue survey of that district was executed.

In addition, a large scale survey of Shillong was undertaken and carried through to completion.

54. The party took the field early in December, having been delayed in obtaining coolies; but notwithstanding the lateness of their arrival in the plains, several of the native establishment were struck down with cholera.

The country surveyed in South Sylhet was much the same in character as that previously met with and described in last year's Report, consisting of low hills covered with dense bamboo and tree jungle, rendering the work of survey tedious and difficult. Notwithstanding this, the party succeeded in completing the detail survey of an area of 296 square miles, to aid which an area of 250 square miles of triangulation was also executed and computed out in the field; this completes the portion of work allotted to this party in South Sylhet.

55. The Department, and in a very special manner, this party, has to regret the sad loss of Mr. A. W. Chennell, Surveyor, 4th grade, who died in Bombay Harbour on the 5th October 1883. The disease to which he succumbed originated in an accident he met with during the previous season while traversing a stream in the Tipperah Hills. He had always been mentioned in the highest terms by the officers under whom he served during the 19 years he had been in this Department, and was one of the surveyors who was specially selected for service in Afghanistan during the late war. His loss to this Department is therefore great.

56. During the coming season,‡ Lieutenant-Colonel Woodthorpe with a portion of his party will be employed in surveying the head of the Dehing Valley and the hitherto unexplored portions of the Patkoi range. It is hoped that this experienced officer will, during the course of the work, have an opportunity of overlooking the unknown country to the east of our frontier, and thus obtain some idea of the mountain systems at the head of the Irrawaddy river.†

‡ *While proceeding to the field, Colonel Woodthorpe's progress has been arrested by a raid by the Akas on British territory, and, at the desire of the Chief Commissioner of Assam, he has turned aside, and will probably effect a survey of the unknown and hitherto inaccessible hill tract occupied by that tribe.*

* Major Wilmer reports that he has much pleasure in recording the satisfaction given by Mr. W. H. Sattersom. He speaks well of all his assistants, more especially of Messrs. Wainwright and Kitchen, who are very favourably mentioned.

† Lieutenant-Colonel Woodthorpe reports well of all his assistants, more especially of Mr. Ogle, who, he states, has worked most energetically.

VII.—THE BURMA TOPOGRAPHICAL SURVEY.

Personnel.

Mr. H. Horst, Officiating Deputy Superintendent, 3rd grade, in charge from 15th December 1882.
Mr. E. C. Barrett, Assistant Superintendent, 1st grade.
Mr. G. A. McGill, Surveyor, 1st grade (in charge up to 14th December 1882).
Mr. J. H. Wilson, Assistant Surveyor, 1st grade.
„ C. P. Torrens „ „ „
„ C. Graham „ „ 2nd „
Sub-Surveyor Modhu Sudun Dutt.
„ Kalka Pershad,
and 12 others.

57. At the wish of the Chief Commmissioner of British Burma, the detail survey of certain forest reserves of the Tharawaddy district had been undertaken by the revenue party employed on the cadastral survey of that district. After the experience of one season, and with a view to more quickly satisfying the pressing demands of the Forest Department for large scale maps of their reserves, it was decided* to organize a special topographical party for work in British Burma.

* *Vide* Revenue and Agricultural Department letter No. 236, dated 3rd July 1882.

58. The work which the Chief Commissioner desired that this party should undertake may be classified under three heads:—

(*a*) The survey of all the lands in the plains which have not been cadastrally surveyed.
(*b*) The survey of all the hilly tracts.
(*c*) All the reserved forests.

The scales to be adopted were, for (*a*) that of 2″ = 1 mile; (*b*) that of 1″ = 1 mile; and (*c*) the scale of 4″ = 1 mile.

59. Under this latter head fall all actually appropriated reserves and those areas proposed to be reserved as forests, whether technically "reserved forests," "village forests," or "fuel reserves." Any expenditure incurred in surveying the forest areas in more detail than is customary in the case of a survey for ordinary topographical purposes is to be met by the Local Government as a forest charge.

60. A topographical party was therefore organized, consisting in a great measure of the late No. 7 Party hitherto employed in Rajputana, and recruited by some surveyors who had been previously attached to the Hanthawaddy Cadastral Party, and were employed in the survey of the forest reserves which had been undertaken by that party.

It was decided to confine the survey, for the present, to the western slopes of the Pegu Yoma, the field of operations being bounded on the east by the ridge of the Pegu Yoma, and on the west by the Irrawaddy river.

61. The party, the charge of which of late had been in the hands of Mr. G. A. McGill, Surveyor, 1st grade, and which devolved on Mr. Horst in December, upon his joining it at Rangoon, took the field in the middle of that month and commenced work in the Thoneseh Forest Reserve, situated in the south of the Tharawaddy district. A certain amount of the ground had been traversed during the previous field season by the Hanthawaddy Cadastral Party, and thus prepared for detail survey. This was a great assistance to Mr. Horst's party, who were thus enabled to commence the detail survey at an earlier date than they would have otherwise been able to do.

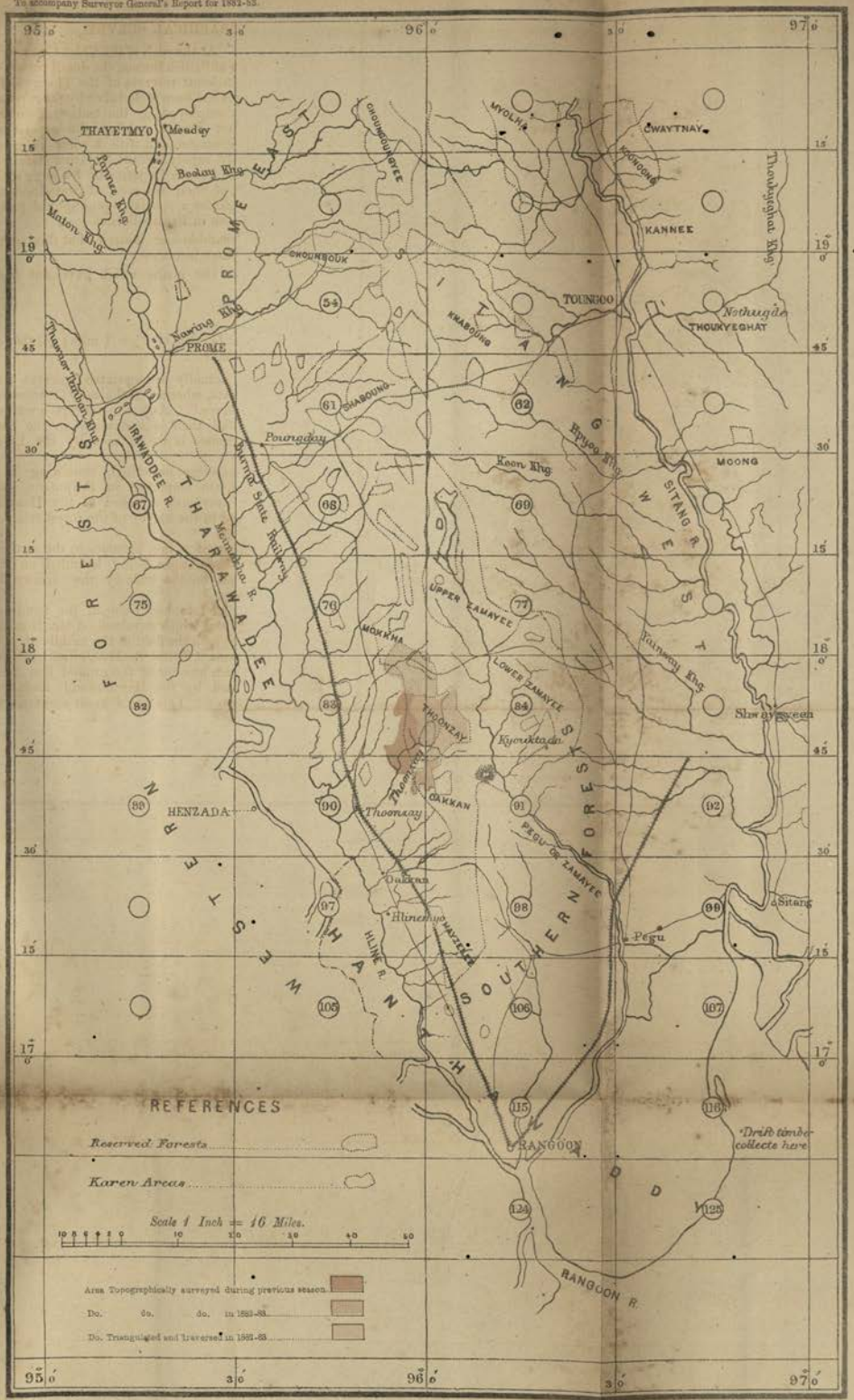
62. The country under survey presented extraordinary difficulties. The ground is hilly and broken, all the features being unusually minute. It is clothed with a dense forest, having a thick and almost impenetrable undergrowth, tangled and matted with cane and other creepers. Through this the surveyor has to cut his way laboriously foot by foot. The forest is so dense that, even when the track is cleared, the surveyor only becomes cognisant of such topographical features as are directly cut by it; he cannot trace them ten yards on either hand. Mr. Horst's remarks of the country surveyed and of the difficulties experienced will be found in the Appendix

63. Undoubtedly the worst enemy which the party had to face was the unhealthiness of the country; the native establishment suffered terribly from fever and dysentery, the average proportion prostrated through sickness throughout the season being 40 per cent. The mean strength of the menial establishment was 364. Of these, 26 died, 19 were invalided, and about 20 others were so ill at the termination of the field season that they had to be carried down to Letpadan.

INDEX MAP

OF THE BURMA TOPOGL. SURVEY.

To accompany Surveyor General's Report for 1882-83.



Photozincographed in the Survey of India Offices, Calcutta.

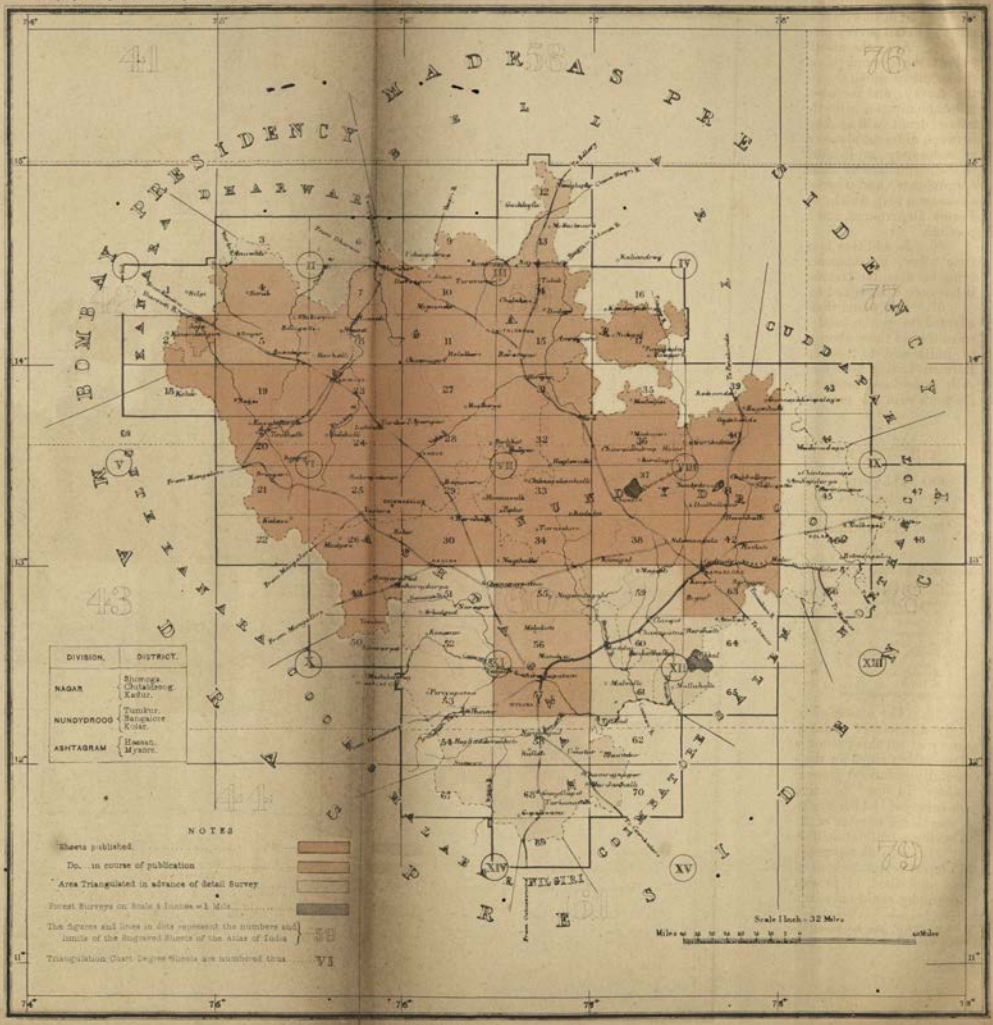
Published under the direction of Colonel G. C. DePrée, R.C., *Officiating Surveyor General of India,*
Survey of India Offices, Calcutta, December 1883.

Nos. 8 & 9 PARTIES.

INDEX TO THE SHEETS OF THE MYSORE TOPOGRAPHICAL SURVEY,

On the Scale of 1 Inch = 1 Mile.

To accompany Surveyor General's Report for 1882-83



Published under the direction of Colonel G. C. DePrée, R.C., Officiating Surveyor General of India,
at the Survey of India Offices, Calcutta, February 1884.

64. In the face of all these difficulties it is not surprising that the party, nearly all unused to surveying in this description of country, were only able to complete in this their first season's work the small amount of 49 square miles of detail survey on the scale of 4″ = 1 mile.

65. After the manner of the forest surveys hitherto executed in India (where the ground is vastly more favourable), the detail was shown with all the accuracy which the scale would allow. With a view, however, to quicken the survey, and increase the out-turn of completed work, it has been decided, in communication with the local authorities, that a considerable amount of minor detail will in future be omitted. The main ridges, streams, boundaries between different classes of reserves, and other important detail will be shown as accurately as heretofore. Minor detail will be either omitted or sketched in such a manner by dotted lines or otherwise as to show that it is merely approximate, and possesses no claims to accuracy. By these means it is hoped to secure a map which, while answering all the essential requirements of the Forest Department, can be executed far more quickly than would be otherwise possible.

66. In addition to continuing the survey of the forest reserves, should time allow, a commencement will be made with the mapping of the plains lying between the Irrawaddy and Mimakha rivers, a tract of country which it has been determined to survey on the scale of 2″ = 1 mile.

67. It is found that natives of Chota Nagpore are in every way most adapted to the menial work of the Survey Department in Burma; and the recruiting of these aboriginals, their shipment to Burma, and return passage to India add to the responsibilities of the executive officer. In the same way Burmans having been found quite unqualified for surveying in the face of such difficulties, measurers of all classes have to be sent over from India for work with this party.*

VIII.—THE MYSORE SURVEY (No. 8 TOPOGRAPHICAL PARTY).

68. The party was employed in continuing the topographical survey of the Mysore province on the scale of 1″ = 1 mile, and proceeded into the field early in November.

69. The operations consisted of triangulation and detail survey. The former was extended over an area of 2,500 square miles in the south-west portion of the Mysore district, on the borders of Coorg and Malabar. A considerable part of this country in the Heggaddevankote taluk is exceedingly wild, covered with dense forest, and very unhealthy. Much difficulty was experienced in this inhospitable tract, and the detachment employed there suffered severely from fever.

Personnel.

Major H. R. Thuillier, R.E., Deputy Superintendent, 1st grade, in charge.
Lieutenant F. B. Longe, R.E., Offg. Assistant Superintendent, 1st grade.

Mr. E. S. P. Atkinson, Surveyor,	3rd grade.	
„ L. J. Peacock	„	4th „
„ A. J. James	„	4th „
„ W. Stotesbury	„	4th „
„ F. Kitchen, officiating	„	4th „
„ H. Todd	„	4th „
„ J. Kennedy Assistant	„	3rd „
„ J. A. Higgs	„	3rd „

and 11 native sub-surveyors.

70. The season's final topography covers an area of 4,644 square miles in the districts of Shimoga, Túmkúr (late Chitaldroog), and Mysore. The survey of all this ground was close and searching, the average number of plane-table fixings for the season's work is 11·2 per square mile. The work was carefully examined throughout by 640 miles of check routes and traverses, besides "in situ" examinations; and with the exception of the work of one sub-surveyor, which was rejected, all the field sections stood the tests very well. A very large number of heights have been fixed, which have aided materially in giving a truthful delineation of the ground.

71. Of this topography, an area of 1,308 square miles is in the Malnád, or hill forest region, where the difficulties and obstacles to quick progress have been described in previous reports, and which were again met with. The topography could only be obtained by traversing with the plane-table and chain.

* Mr. Horst, who has himself displayed much energy, zeal, and resource, reports very favourably of the work of Messrs. Wilson, Torrens, and Graham, and, with one exception, of his sub-surveyors.

The remaining area is in the "Maidan," or open country, where the more rapid means of working by intersections from fixed points could be carried out. The health of the detachments employed on the detail survey was again unusually good, and to this may be attributed in some measure, the successful out-turn obtained. The Native surveyors have aided considerably towards the large out-turn. Great credit is due to Major Thuillier for the careful arrangements and supervision which have rendered this party unusually efficient in all branches, and have now resulted in an ample out-turn of final work.

72. During the recess, the mapping of the whole of the season's topography has been completed, comprising the following Standard Sheets, viz. 1, 2, 4, 5, 6, 7, 8, 9, 12, 13, 55, and 56. Triangulation charts of degrees I, II, and III have also been prepared and the computations have been brought up to date. In addition to the ordinary recess work, the survey of the town and cantonment of Bangalore, on the scale of 12″ = 1 mile, required by the Mysore Government, has been commenced. The triangulation covering an area of about 40 square miles, was completed and 29·2 linear miles of boundary and road traverses run.

73. The total cost of the year's operations gives an average rate of Rs. 18-5-6 per square mile for final survey.

74. During the next season the detail survey on the 1-inch scale will be carried on in sheets 51, 52, 53, 59, 60, 61, 64, and 65. The survey of the town of Mysore on the scale of 12″ = 1 mile will be undertaken at the request of the Mysore Government. The triangulation will be extended in degrees IX and XIII during the year, which will complete the triangulation of the whole province. The large scale survey of the town and cantonment of Bangalore will be continued during the next recess, as opportunities offer.*

IX.—THE KOHAT TOPOGRAPHICAL SURVEY.

75. As anticipated in the last report, this party has, during the season under review, successfully brought to completion the topographical survey of the Kohat District.

Personnel.

Major T. H. Holdich, R.E., Deputy Superintendent, 2nd grade, in charge.
Lieutenant the Hon'ble M. G. Talbot, R.E., Assistant Superintendent, 1st grade, up to 30th April 1883.
Lieutenant H. M. Jackson, R.E., Officiating Assistant Superintendent, 1st grade, from 11th June to 30th September 1883.
Mr. T. E. M. Claudius, Surveyor, 4th grade.
„ W. W. McNair „ 4th „ up to 18th February 1883.
„ F. E. Wardo, Assistant Surveyor, 2nd grade, from 1st June 1883.
„ R. F. Warwick, Assistant Surveyor, 3rd grade, from 15th August 1883.
Sub-Surveyor Esuf Sharif.
„ Imam Bux.
„ Syud Ullah,
and 5 others.

The triangulation had been previously completed, and it only remained to execute the detail survey of about 1,227 square miles of the country lying on the eastern edge of the district along the Indus, and to determine a number of additional heights for insertion on the fair maps. In addition, a large scale plan of the city and cantonment of Kohat was undertaken and completed during the season.

76. During the prosecution of the topographical survey of the British territory, every effort has been made to increase our knowledge, and complete the topography of the trans-frontier country, an accurate map of which is of such vital importance in the successful administration of a border district.

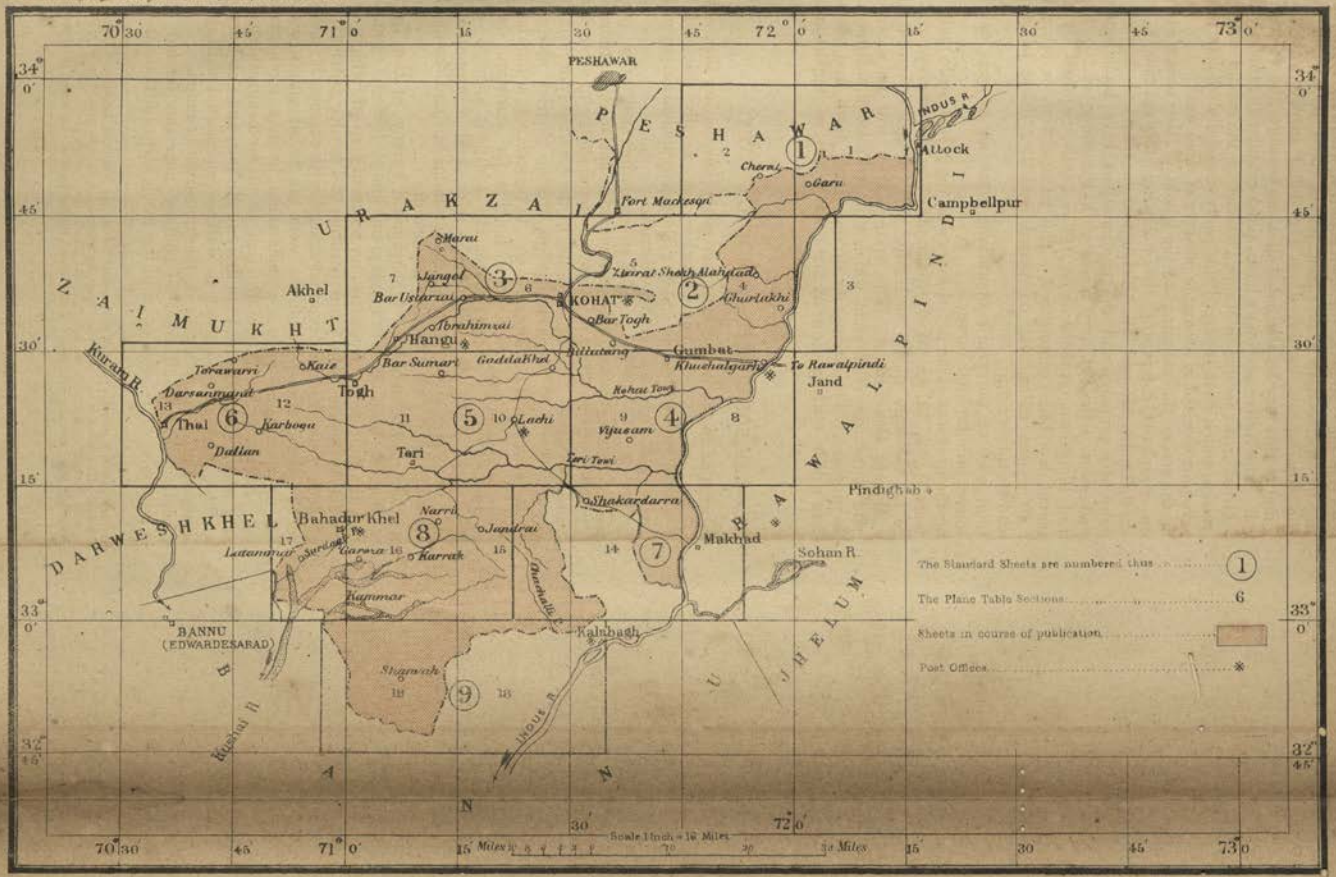
To conduct such trans-frontier reconnaissances with success, it is above all things needful to open up friendly relations with the tribal chiefs, without whose protection or connivance such reconnaissances become too hazardous to be undertaken. In this respect Major Holdich is to be congratulated on having in his party such men as Messrs. Claudius and McNair, and Sub-Surveyor Esuf Sharif, to whose tact and judgment, as well as professional skill, is due the successful filling up of so many blanks in our trans-frontier maps.

With the exception of a small tract of country near the Gumal pass, we are now in possession of reliable maps of the whole strip of trans-frontier

* Major Thuillier reports in very favourable terms of the good aid he has received from Lieutenant Longe, R.E., and of his ability and energy. He commends the exertions of all his European assistants, and especially brings to notice the good services of Messrs. Pocock, Stotesbury, and Todd. The Native surveyors have, as a body, worked remarkably well, the following being specially mentioned: Janki Dass, Raghavayengar, Lachman Daji, and Balaji Dhondiba.

INDEX TO THE SHEETS OF THE TOPOGRAPHICAL SURVEY, DISTRICT KOHAT.

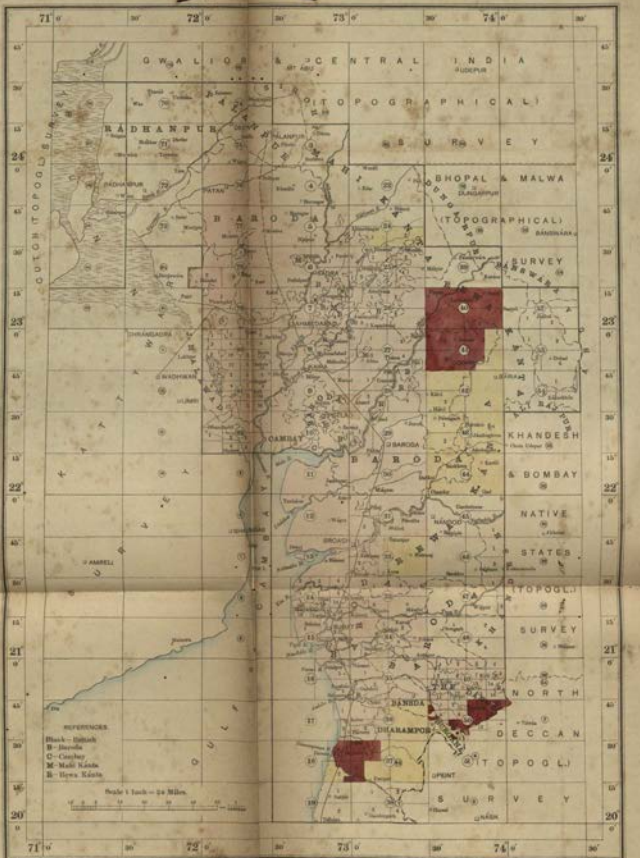
To accompany Surveyor General's Report for 1882-83



Published under the direction of Colonel G. C. DePrée, R.C., Officiating Surveyor General of India,
at the Survey of India Offices, Calcutta, February 1884.

SURVEY OF INDIA.

INDEX CHART of the GUZERAT SURVEY.



territory extending from the Kabul River on the north to the Gumal on the south—a result in a great measure due to the interest taken in the work by Major Holdich.

77. Concurrently with the reconnaissances of the adjacent trans-frontier territory, explorations were pushed forward, as opportunity arose, into hitherto untraversed districts in Afghanistan and elsewhere; but as trans-frontier work is conducted on different principles from those which regulate ordinary topography, the report on all work of such nature will be included in the geographical section of this report.

78. The previous recess season having been mainly utilized to complete the fair mapping of the surveys in Northern Afghanistan, the work of drawing the Standard Sheets of the Kohat District Survey had unavoidably fallen into arrears. The amount of mapping that consequently fell on this party during the recess under report, was far more than their unaided efforts could possibly accomplish. Advantage was therefore taken of the presence of various other survey parties in recess at Mussooree, and they were requested to do what they could to lighten the work of the Kohat Party. By the assistance of the No. 5 Topographical Party and the No. 3 Revenue Party, Major Holdich was enabled to complete for publication, the whole nine Standard Sheets in which the survey of the Kohat district is comprised.

79. The work allotted to this party being now completed, it has been broken up; Major Holdich, with the greater number of the assistants, being transferred to the Baluchistan Survey.*

X.—THE GUZERAT TOPOGRAPHICAL SURVEY.

80. The operations of this party, carried on under Colonel Haig's charge, have been of four descriptions or classes, *i.e.*—

Personnel.

Colonel C. T. Haig, R.E., Deputy Superintendent, 2nd grade, in charge.
Captain J. R. Hobday,† S.C., Assistant Superintendent, 1st grade.
Lieutenant G. B. Hodgson, S.C., Probationery Assistant Superintendent, 2nd grade. (Joined 13th September 1883.)
Mr. A. D'Souza, Surveyor, 1st grade.
„ C. H. McAfee „ 4th „
„ C. Tapsell, Assistant „ 1st „
„ G. D. Cusson „ „ 1st „
„ S. F. Norman „ „ 2nd „
„ C. A. Norman „ „ 3rd „
„ A. George „ „ 3rd „
Sub-Surveyor Gopal Vishnu.
„ Lakshman Rao Ghorpade.
„ Bhan Govind.
„ Gobind Gopal,
and 26 others.

First, the ordinary topographical surveying of Native States, executed on the scale of 2 inches = 1 mile, and published on the 1-inch scale.

Second, the preparation of a series of maps on the 2-inch scale, comprising British territory in detail and foreign territory in skeleton, utilizing in the former the maps of the Bombay Revenue and Settlement Surveys so far as practicable.

Third, the survey of the Dang forests and of nine adjacent villages in the Násik district on the 4-inch scale.

Fourth, the survey of the Panch Máháls, incorporating the fiscal details of the Revenue Survey village maps, and including forest boundaries on the 4-inch scale.

81. The topographical operations were carried on in three different localities. One of these, it will be seen from the index chart, comprises sheet 40 and about three-fourths of sheet 41. It includes the large towns of Godhra (capital of the Panch Máháls) and Lúnávada, besides others of lesser note; is watered by the Mahi, the Kusi, and the Pánam Rivers, and is traversed for a short length to the south by the Bombay-Baroda, and Central India Railway. The latter proceeding from Páli has now reached Godhra. Another locality falls in sheets 18 and 37; it includes the Portugese town of Daman, besides the British towns of Wápi, Udvádə, Kolak, the fort of Bagváda, &c., and is watered by the rivers Daman-Ganga, Pár, and Kolak: these latter are fed by numerous and tortuous water-courses, which required delineating, and so, considerably increased the work of surveying. The third locality falls in sheet 50, where the Dangs presented no novelty of feature requiring notice.

* Major Holdich reports very highly of the aid rendered by Lieutenant Talbot, and remarks—"It is due to the thoroughness of Mr. Talbot's instructions that * * * subsequently turned out such an excellent reconnaissance of Birmal."
He speaks in terms of the highest praise of the services of Messrs. Claudius and McNair, as also of Sub-Surveyor Esuf Sharif.

† Absent while officiating in charge of other parties up to 15th December 1882, and from 21st August 1883 to end of year under report.

82. The area topographically surveyed is sub-divisible territorially, and in sheets as follows:—

States and Talukas.	Sheets.					Total.
	18	37	40	41	50	
	Sq. m.	Sq. m.	Sq. m.	Sq. m.	Sq. m.	Sq. m.
Párdi (Surat)	61·0	88·5	.....	.....	.....	149·5
Bulsár (do.)	.....	7·2	.....	.....	.....	7·2
Kalvan (Násik) ...	.....	.....	.....	.....	30·6	30·6
Godhra (Panch Máhals) ...	.....	.....	54·1	365·1	.....	419·2
Dangs	.....	.....	.....	.....	127·2	127·2
Daman	28·2	16·4	.....	.....	.....	44·6
Bálásinor	.....	.....	45·3	.....	.....	45·3
Lúnávada	.....	.....	226·2	23·6	.....	249·8
Sunth	.....	.....	199·3	.....	.....	199·3
Kadána	.....	.....	1·0	.....	.....	1·0
Báriya	.....	.....	5·2	.....	.....	5·2
Sanjeli	.....	.....	16·1	.....	.....	16·1
Dharampor	.....	36·7	.....	.....	.....	36·7
Total ...	89·2	148·8	547·2	388·7	157·8	1331·7

83. This total area of 1331·7 square miles sub-divides into 602·6 square miles on the 4-inch and 729·1 square miles on the 2-inch scale. The former includes completion of the Dang survey, excepting a small tract in Ketak Karúpara (sheet 48), of which cognizance has only recently been obtained, so that practically speaking, the survey of that valuable but trying tract known as the Dangs stands completed. The other area of 729·1 square miles includes the remaining portion of British territory to be published on the 2-inch scale, as explained above, under class second, excepting a small portion of a village in the Paránt(j táluka, falling in sheet 24; thus, the work of this class also may be said to be finished.

84. The operations under notice complete a total of about 17,000 square miles topographically surveyed in Guzerat, leaving a balance of about 13,500 square miles to complete the survey of the province. Contrasting the present season's out-turn with that of the preceding year, the 2-inch work is found to be some $\frac{5}{12}$ths less, and no work was required on the 12-inch scale; but on the other hand, the area on the large and intricate scale of 4-inches has increased four-fold from 152 square miles, so that, on the whole, satisfactory progress has been made.

85. The area triangulated and traversed was 858 square miles, which added to the balance from last year's operations, leaves a remainder of some 3,000 square miles in advance for future topographical operations. The water-level was employed as before over all suitable ground on the 4-inch scale.

86. The fair-mapping for publication by photo-zincography is considerably in arrears, but it is expected that these will be cleared off in the ensuing year.

87. The party was inspected early in November by Mr. Hennessey, Officiating Deputy Surveyor-General, in charge Trigonometrical Branch.

XI.—THE CUTCH TOPOGRAPHICAL SURVEY.

88. The party having been conducted into the field by Captain Hobday, officiating in charge, he was relieved by Colonel Pullan on his return from privilege leave, and the subsequent operations were conducted as usual by the latter officer. It will be remembered that the ordinary scale of 2-inch (for publication on 1-inch) adopted for the mainland of Cutch, was reduced to the more suitable scale of $\frac{1}{2}$-inch for the Rann. In the season under notice, however, no portion of the latter tract came under topographical survey, which, was therefore, all on

Personnel.

Lieutenant-Colonel A. Pullan, S.C., Deputy Superintendent, 3rd grade, in charge from 5th December 1882.
Captain J. R. Hobday, S.C., Assistant Superintendent, 1st grade, in charge to 4th December 1882.
Mr. N. C. Gwynne, Surveyor, 4th grade.
„ W. A. Fielding, Assistant Surveyor, 1st grade.
„ G. T. Hall, Assistant Surveyor, 1st grade.
„ P. F. Prunty, „ „ 2nd „
Sub-Surveyor V. R. Gadbole.
„ N. D. Patwardhan.
„ G. R. Bhopatkar,
and seven others.

TRIGONOMETRICAL BRANCH, SURVEY OF INDIA.

INDEX CHART OF THE CUTCH TOPOGRAPHICAL SURVEY.

The numerals (1) (2) (3) &c. indicate the sheets on the scale of 1 inch to the mile.

The smaller numerals as (22) or (31) indicate the sheets of adjoining surveys.

The originals of the 1-inch sheets are drawn on the 3-inch scale and are divided into 4 sections, known as N.E., N.W., S.E., and S.W.

Scale 1 inch = 16 miles 10 5 0 10 20 30 40 50 1/1140480

Dessins contrary Topographically Surveyed up to 1881.81

" " " " " " 1881.82

" " Triangulated and Dissected in advance

G. C. GUERRIER, Lith.

INDEX TO THE

N. W. PROVINCES SURVEY.

66 N.W.
66 S.W.
67 N.W.
67 S.W.
68 N.W.
68 S.E.
SAHARANPUR
MUZAFFARNAGAR
MEERUT
DELHI
BULANDSHAHR
ALIGARH
DEHRA DOON
Hardwar
Roorkee
Meerut
Delhi
Aligarh
Agra
Mathura
Etawah
Cawnpore
Allahabad
Mirzapur
Benares
Ghazipur
Jaunpur
Azimgarh
Gorakhpur
Basti
Fyzabad
Sultanpur
Partabgarh
Allahabad
Mirzapur
Jhansi
Lucknow
Unao
Rae Bareli
Sitapur
Hardoi
Kheri
Bareilly
Moradabad
Budaon
Shahjahanpur
Pilibhit
Bijnor
Rampur
Nainital
Almora
Garhwal
Tehri
Dehra Doon
Simla
Ambala
Karnal
Rohtak
Hissar
Gurgaon
Muttra
Agra
Etawah
Cawnpore
Fatehpur
Banda
Hamirpur
Jalaun
Gwalior
Dholpur
Bharatpur
Alwar
Jeypore
Ajmere
Merwara
Kotah
Bundi
Tonk
Udaipur
Chittor
Bhilwara
Shahpura
Kishengarh
Jodhpur
Sirohi
Pali
Marwar
Jaisalmer
Bikaner
Sirsa
Hansi
Rewari
Jhajjar
Kanaud
Thanesar
Ambala
Simla
Subathu
Kotgarh
Kulu
Lahul
Spiti
Kangra
Nurpur
Chamba
Suket
Mandi
Bilaspur
Jubbal
Keonthal
Baghat
Sirmur
Kalsia
Loharu
Dujana
Pataudi
Ferozepore
Lahore
Amritsar
Gurdaspur
Sialkot
Gujrat
Shahpur
Jhelum
Rawalpindi
Hazara
Peshawar
Kohat
Bannu
Dera Ismail Khan
Dera Ghazi Khan
Multan
Montgomery
Lyallpur
Jhang
Muzaffargarh
Leiah
Mianwali
Attock
Khushab
Bhawalpur
Bahawalnagar
Fazilka
Ferozepore
Muktsar
Bhatinda
Faridkot
Patiala
Jind
Nabha
Sangrur
Kaithal
Pehowa
Thanesar
Shahabad
Ladwa
Narnaul
Mahendragarh
Dadri
Jhajjar
Rewari
Gurgaon
Palwal
Ballabgarh
Muttra
Mahaban
Kosi
Sadabad
Hathras
Mursan
Agra
Fatehpur Sikri
Firozabad
Jalesar
Etah
Mainpuri
Shikohabad
Bah
Jaswantnagar
Bharthana
Etawah
Auraiya
Dibiyapur
Kanauj
Farrukhabad
Fatehgarh
Kampil
Shamsabad
Mohamdi
Khairabad
Sitapur
Misrikh
Sandila
Hardoi
Shahabad
Pihani
Bilgram
Sandi
Lucknow
Unao
Purwa
Safipur
Bangarmau
Rae Bareli
Dalmau
Partabgarh
Salon
Jagdishpur
Amethi
Gauriganj
Sultanpur
Musafirkhana
Jagdishpur
Isauli
Akbarpur
Tanda
Fyzabad
Sohawal
Bikapur
Gonda
Colonelganj
Nawabganj
Utraula
Balrampur
Tulsipur
Bansi
Basti
Domariaganj
Bansgaon
Gorakhpur
Padrauna
Hata
Kasia
Deoria
Salempur
Rudhauli
Basharatpur
Khalilabad
Bansi
Mehndawal
Nagar
Tamkuhi
Bhatpar
Gauri Bazar
Maharajganj
Nichlaul
Paniara
Sohgaura
Gorakhpur
Barhaj

the 2-inch scale; the sheets surveyed being Nos. 6, 7, 8, and the remainder, or nearly half of 23, as shown in the index. The country in 6 and 7 is hilly, rising at Sura-Gundára abruptly to a height of 893 feet above sea-level; it is also covered with low jungle, and intersected by numerous tidal creeks and ravines, making the work of the surveyor, laborious and difficult. Elsewhere but few obstacles were encountered. The area of operations includes the towns of Mundra, Naliya, Jakháwu, Tera, Kothára, and Suthri, besides two places of pilgrimage—Mátánomadh (Mhur) and Náráyan Sarovar—the former of which is also well known for its manufacture of alum. The drainage passing through the season's work was insignificant.

89. The area triangulated in advance falls in sheets 26 to 29, which it will be seen, include portions of both the mainland and the Rann.

In all 1,632 square miles were topographically surveyed on the 2-inch scale, 740 linear miles were traversed, and 2,124 square miles were triangulated. These items shew individual increases on the out-turn of the previous season, especially that given last, which is about $\frac{3}{5}$ths in excess; but on the other hand, no topography on the $\frac{1}{2}$-inch scale was required or executed: thus, on the whole, the progress has been normal and satisfactory.

In respect to recess duties, there are practically no arrears.

90. The party was inspected by Mr. Hennessey, Officiating Deputy Surveyor-General, in charge Trigonometrical Branch.*

XII.—BULANDSHAHR, ALIGARH, AND ETAH DISTRICTS. NORTH-WEST PROVINCES. (No. 8 PARTY, REVENUE BRANCH.)

91. This party, during the field season, has been under the charge of Mr. E. T. S. Johnson, late Deputy Superintendent, 3rd grade, under whose charge it remained until 29th April 1883, on which date Mr. Johnson was obliged to retire, having attained the age of 55 years. Mr. G. H. Cooke, Assistant Superintendent, received charge of the party intermediately, and made it over, on 12th May, to Mr. J. O. N. James, Deputy Superintendent, who has held charge throughout the recess. Field operations commenced on 12th October 1882, and were continued up to 20th April 1883, on which date the party returned to its recess quarters at Mussooree.

Personnel.

Mr. E. T. S. Johnson, Deputy Superintendent, 3rd grade, in charge up to 28th April 1883.
Mr. G. H. Cooke, Officiating Deputy Superintendent, 4th grade, in charge from 29th April to 11th May 1883.
Mr. J. O. N. James, Officiating Deputy Superintendent, 2nd grade, in charge from 12th May 1883.
Mr. James Todd, Surveyor, 2nd grade, on furlough from 16th April 1883.
Mr. C. W. Wilson, Assistant Surveyor, 1st grade.
„ C. W. F. Seyers, ditto.
27 Sub-Surveyors, and others.

92. The principal operation on which the party is engaged is a 2-inch topographical survey of the Dooab between the Ganges and Jumna rivers, which has been carried on during the past season, chiefly in the Bulandshahr and Aligarh districts. While for the riverain, low-lying tracts of both rivers, bordering on the area surveyed topographically, the scale has been increased to 4 inches to a mile; and while in the topographical area village boundaries have not been surveyed, but taken from settlement maps, in the riverain area, the boundaries have been surveyed afresh. The separate areas on the different scales and in the different districts are shown in the following statement:—

District.	On 2-inch scale.	On 4-inch scale.	Total.
	Sq. miles.	Sq. miles.	Sq. miles.
Bulandshahr	523·43	67·65	596·08
Aligarh	1224·26	101·22	1325·48
Etah	26·95	8·40	35·35
Budaun	.....	58·38	58·38
Gurgaon	.....	67·49	67·49
Delhi	.....	3·30	3·30
Total ...	1779·64	306·44	2086·08

* Colonel Pullan acknowledges the services rendered to his party during his absence, by Captain Hobday and also favourably notices the work executed by all his assistants.

93. The civil station and city of Aligarh, covering an area of 4·68 square miles, has been surveyed on the scale of 6 inches to a mile. Skeleton traversing, preparatory for topographical survey during the following season, was extended over an area of 869 square miles in districts Aligarh and Etah.

94. The topographical survey on both scales has been carefully tested by check surveys, done almost entirely by the European officers, to the extent of 440 linear miles. The angular work of the traverses has been checked by 69 observations for azimuth, and the chain measurements have been brought into accord with the triangulation distances of the Great Trigonometical Survey by means of connections on five stations.

95. The trijunction points of village boundaries, at which there are low masonry platforms, have all been adopted as traverse stations, and the intermediate stations between trijunctions have been marked with specially made pottery cylinders, 2 feet in length by 6 inches in diameter, sunk flush with the ground. The cylinders thus sunk are covered over with a mound of earth, and then delivered to the charge of the village *putwaris* The traverse stations, it is expected, will by this means be permanently preserved, as they are required to be, by paragraph 5 of Government of India circular No. 45S, dated 4th September 1882.

96. The season's out-turn has been mapped on twenty-two 2-inch sheets of the standard size, drawn for reproduction to full scale The same sheets have also been re-drawn in a somewhat exaggerated style, with the minor features generalized and village boundaries omitted, for reduction to the 1-inch scale, and designed so that 4 sheets will form 1 standard sheet on the reduced scale. Special series of 4-inch maps of the riverain tracts on the Ganges and Jumna rivers have also been drawn; and manuscript tracings of these maps have been made to be lodged in Collectors' offices. A reduction of the entire topographical area to the scale of the atlas of India has also been made.

97. On the retirement of Mr. E. T. S. Johnson, who has finished a long career in the department in charge of this party, it is due to him that a record should be given here of the good and faithful service he has rendered to Government.

XIII.—THE SURVEY OF THE SOUTHERN COLLECTORATES OF THE DECCAN, BOMBAY PRESIDENCY.

(No. 11 PARTY, REVENUE BRANCH.)

98. The field operations of this party, which commenced on 15th November 1882, and continued up to 10th May 1883, were carried on under the supervision of Major D. C. Andrew. Major Andrew remained in charge during the recess up to 20th of August 1883, when he proceeded on three months' privilege leave, having been relieved by Captain J. R. Hobday, Assistant Superintendent, who was specially transferred to the party for the purpose.

Personnel.

Major D. C. Andrew, Deputy Superintendent, 3rd grade, in charge up to 20th August 1883.
Captain J. R. Hobday, Officiating Deputy Superintendent, 4th grade, in charge from 21st August 1883.
Mr. S. M. Smylie, Surveyor, 3rd grade, on furlough in India from 8th November 1882.
Mr. J. Hickie, Assistant Surveyor, 1st grade.
„ G. C. Swiney, „ „ 1st „
„ R. Todd, „ „ 1st „
„ G. A. Knight, „ „ 2nd „
20 Sub-Surveyors, and others.

99. The survey, which has been purely topographical, but taking cognisance also of village boundaries, has been comprised within the standard sheets

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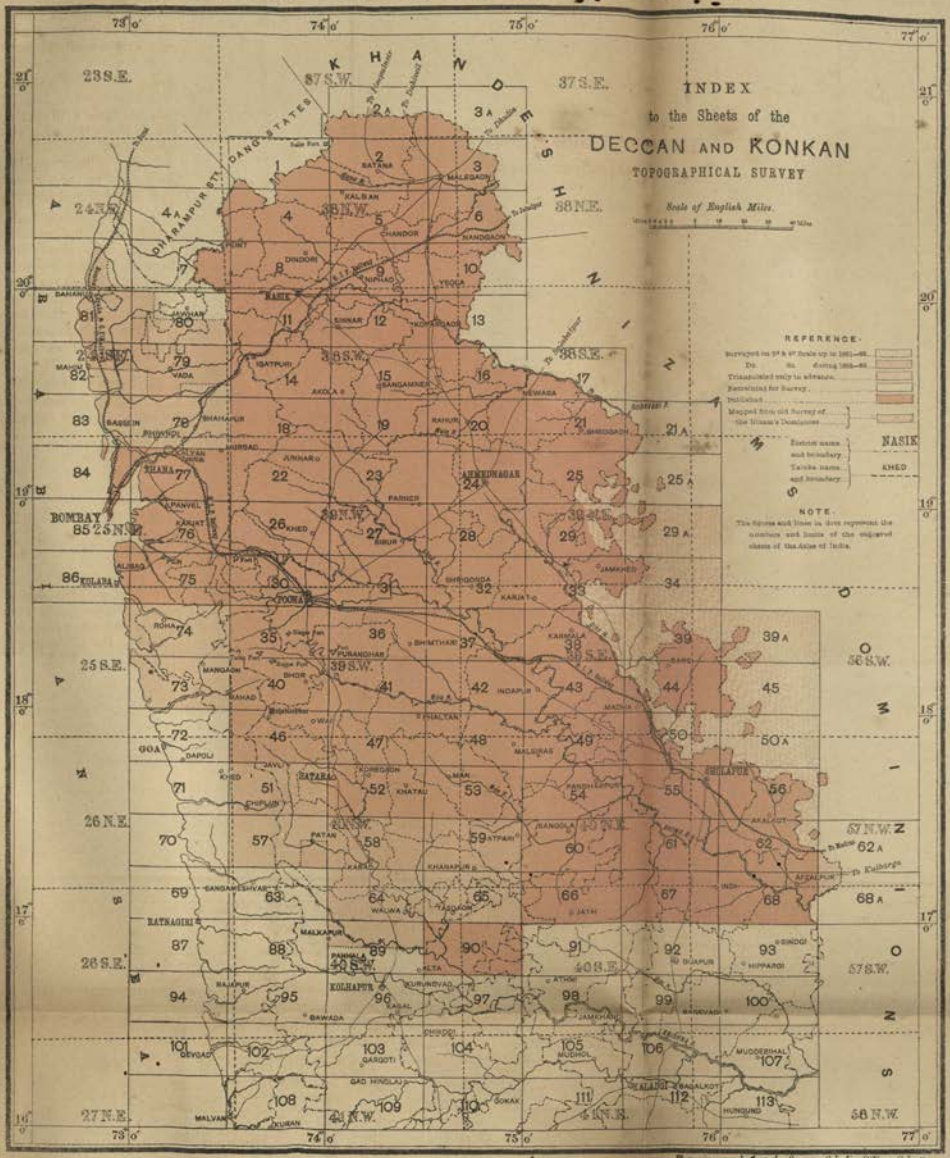
Mr J. O. N. James, Deputy Superintendent, who has held charge of the party during the recess season, reports: - "Mr. G. H. Cooke, Assistant Superintendent, rendered good aid in the season's fair-mapping, and discharged every duty entrusted to him most satisfactorily.

"Messrs C. W. Wilson and C. W. F. Seyers, Assistant Surveyors, gave perfect satisfaction during the field and recess seasons. They are both efficient and zealous assistants, and most exemplary in their conduct."

All the Sub-Surveyors and Computers of the party are said to have done well. The following are mentioned by name, viz., Bhogobutty Churn Chuckerbutty, Clerk; Kedarnath, Computer; Didar Bux, Draftsman; Hidayutulla, Allahdad Khan, Abdul Karim, Irfan Ali, Hira Singh, and Karimulla, Sub-Surveyors.

DECCAN & KONKAN TOPOGRAPHICAL SURVEY.



Published under the direction of Colonel G. C. DePrée, R.C., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, December 1853.

Nos. 51, 58, 59 of the Deccan series, and has included portions of several districts and dependent States, as is shewn in the following statement:—

	Square miles.
Districts—	
Sholapur	7·8
Satara	1242·7
Ratnagiri	259·0
States—	
Aundh	273·4
Akolkot	9·5
Miraj Senior	4·6
Jamkhandi	3·0
Total ...	1800·0

In addition to the above, an area of 1,728 square miles, over which triangulation and skeleton traversing have been completed partly during the previous season and partly during the season under review, is held in readiness for topographical survey during next season.

100. The survey of the town of Pandharpur on the scale of 80 inches to the mile at the expense of the municipality has been carried on by a small detachment during the field and recess seasons. The progress of the work is said to have been to a certain extent interfered with by the large crowds which are attracted to the many fairs held in the town, which is a great place of pilgrimage.

101. The following description of the country is given in the report of the executive officer:—

"The country surveyed during the past season was more rugged and difficult than this party has gone over for some years All three sheets had more or less hilly ground in them. Sheet 51 was entirely covered with hills, being traversed from north to south by the Western Ghâts, in height ranging from 800 to 3,800 feet, from which several spurs shoot out in all directions. The surveyors had considerable difficulty in working in this sheet: not only was there dense jungle, infested in places by wild animals, but the villages consisting chiefly of scattered huts were few in number. The communications between them were circuitous, and supplies were not readily procurable.

"Sheet 58 was tolerably open ground; only the western half of it had a few of the spurs running out from the larger range * * * In sheet 59, there was one small range of hills which entering the sheet at the north in a narrow range spread out into a wide, well cultivated plateau." * * *

102. In the topographical survey, all features have been inserted that the 2-inch scale admitted; and, except in hilly ground, the survey of the limits of cultivation and waste land was carried out the same as last season. The accuracy of the topography has been rigorously tested both by examinations of the plans *in situ*, and also by lines of check surveys. Of the latter kind of test, 259 linear miles were measured By the triangulation 129 new points have been fixed, of which 69 are stations which were visited, the rest being intersected points. A height has been obtained for nearly every station and intersected point fixed by triangulation, and besides, the heights of several traverse stations have been determined.

103. The following are the maps which have been drawn during the recess, and sent to the head-quarter's office:—

4 Sections on the	2-inch scale of	sheet 51.
Ditto	ditto	sheet 58.
Ditto	ditto	sheet 59.

Reductions to the scale of 4 miles to an inch (nearly) for the use of the engravers of the atlas of India have also been drawn.*

* With the exception of one Assistant Surveyor, the European staff of the party are said to have worked well; and there are two exceptions made with regard to the good work generally turned out by the native establishment.

XIV.—HOOGHLY RIVER SURVEY.

(No. 6 PARTY, REVENUE BRANCH)

104. This party under charge of Major S. H. Cowan returned from Hazaribagh, its recess station of 1882, to resume field operations on 20th November. It continued in the field till the 16th June, and then went into recess quarters at Calcutta. Major Cowan remained in charge of the party until 24th July, when he proceeded on furlough having been relieved by Mr. E. C. Barrett.

Personnel.

Major S. H. Cowan, Officiating Deputy Superintendent, 4th grade, in charge up to 24th July 1883; proceeded on furlough on the afternoon of the same date.

Mr. E. C. Barrett, Officiating Deputy Superintendent, 4th grade; transferred from Burma Topographical Party; joined on the afternoon of 7th July 1883; in charge from afternoon of the 24th idem.

Mr. J. S. Pemberton, Surveyor, 3rd grade.

„ C. S. Kraal, Assistant Surveyor, 2nd grade.

„ P. C. H. Smart, Assistant Surveyor, 3rd grade; proceeded on sick leave for 6 months from 8th April 1883; transferred to head-quarters office, Calcutta, while on leave.

26 Sub-Surveyors, and others.

105. The programme of work laid out for the party on the Hooghly river has been completed during the season. On the 16-inch scale, the survey executed has been in the neighbourhood of Barrackpore, a small area near Baranagur, the Kidderpore and Garden Reach suburbs of Calcutta, a part of Howrah, and strips of country along both banks of the river down to latitude 22°30′, that is, a little below Akra. On the 6-inch scale, the survey which has been extended to about half a mile on both banks, was commenced at latitude 22°30′, and taking in the whole of Saugor Island has terminated at the sea. The total length of this part of the survey is 63 miles, but about 6 miles had been surveyed during the previous season. The areas surveyed are 28·79 square miles on the 16-inch scale and 109·30 square miles on the 6-inch scale.

106. Above Diamond Harbour, the stations of the Great Trigonometrical Survey are sufficiently numerous, and in convenient situations, so that the measured traverses of this part of the river survey could be corrected by means of data derived from these alone; but below Diamond Harbour the trigonometrical stations were few, and several temporary points (marine marks) had been moved, so that it became necessary, for the lower part of the river, to supplement the trigonometrical survey by extending a new series of triangles which would terminate at Saugor Island light-house, the position of which based on the existing triangulation charts on a single intersection had also to be checked. Major Cowan personally carried out this triangulation, a subsidiary part of which extends to the east of Saugor Island, fixing points along Channel Creek which separates the island from the Sunderbuns. The positions of 42 points have been determined by the triangulation, which covers an area of 493 square miles.

107. The angular work of the chain traverses was checked by 15 observed azimuths, and the accuracy of the detail survey was tested by 148 linear miles of check surveys.

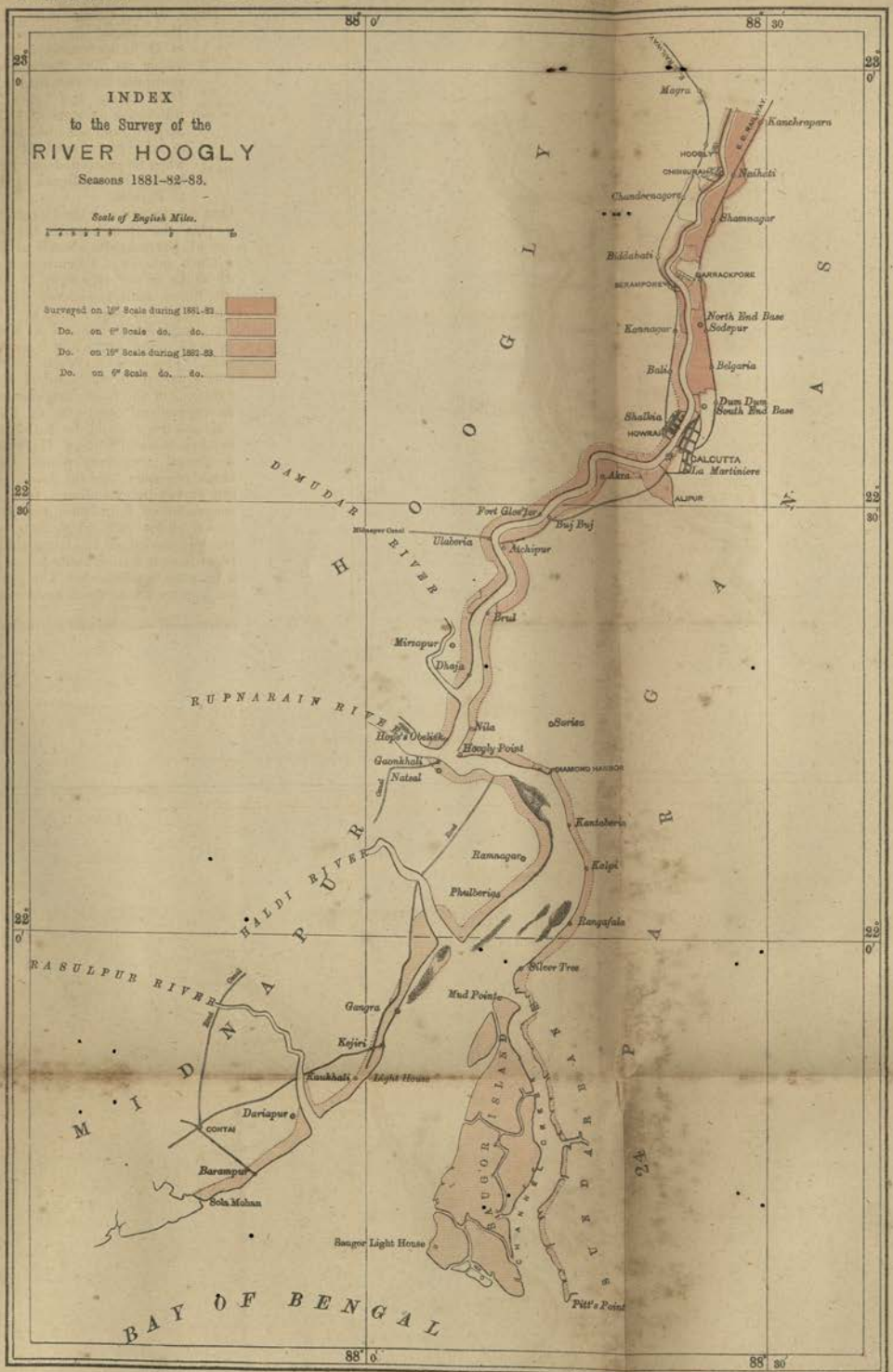
108. Permanent marks, in some cases stone prisms and in others iron screw sockets, have been put down at 244 traverse stations, and 76 sockets specially placed by the Marine Survey have been adopted as traverse stations. The positions of 137 level bench marks fixed in connection with the Leveling and Tidal operations of this Department have also been determined and shewn on the maps.

109. The 16-inch survey has been mapped in 115 sections, of uniform size, 1 minute of latitude × 1 minute of longitude These will be printed on the original scale of survey.

110. The 6-inch series comprises 14 maps in all. Sheets Nos. 1 to 4 have been drawn to the scale of 8 inches to a mile by reduction by means of the pantagraph from the 16-inch sheets. They will be reduced to the scale of 6 inches by photography, and will be printed as they have been drawn, without soundings, as the Marine Survey has not extended above Calcutta. Sheets Nos. 5 to 9 have been drawn on the 6-inch scale by reduction from 16-inch maps; they will not be printed until the river soundings have been added to them by the Marine Survey. Sheets Nos. 10 to 14 are being drawn by the Marine Survey, the traverse data and topographical field sections of the river banks on the 6-inch scale having been supplied by No. 6 Party. Below latitude 22°9′, which is the limit of the 6-inch publications, the river is mapped on 10 sheets

No. 6 REV. PARTY.

LOWER PROVINCES SURVEY.

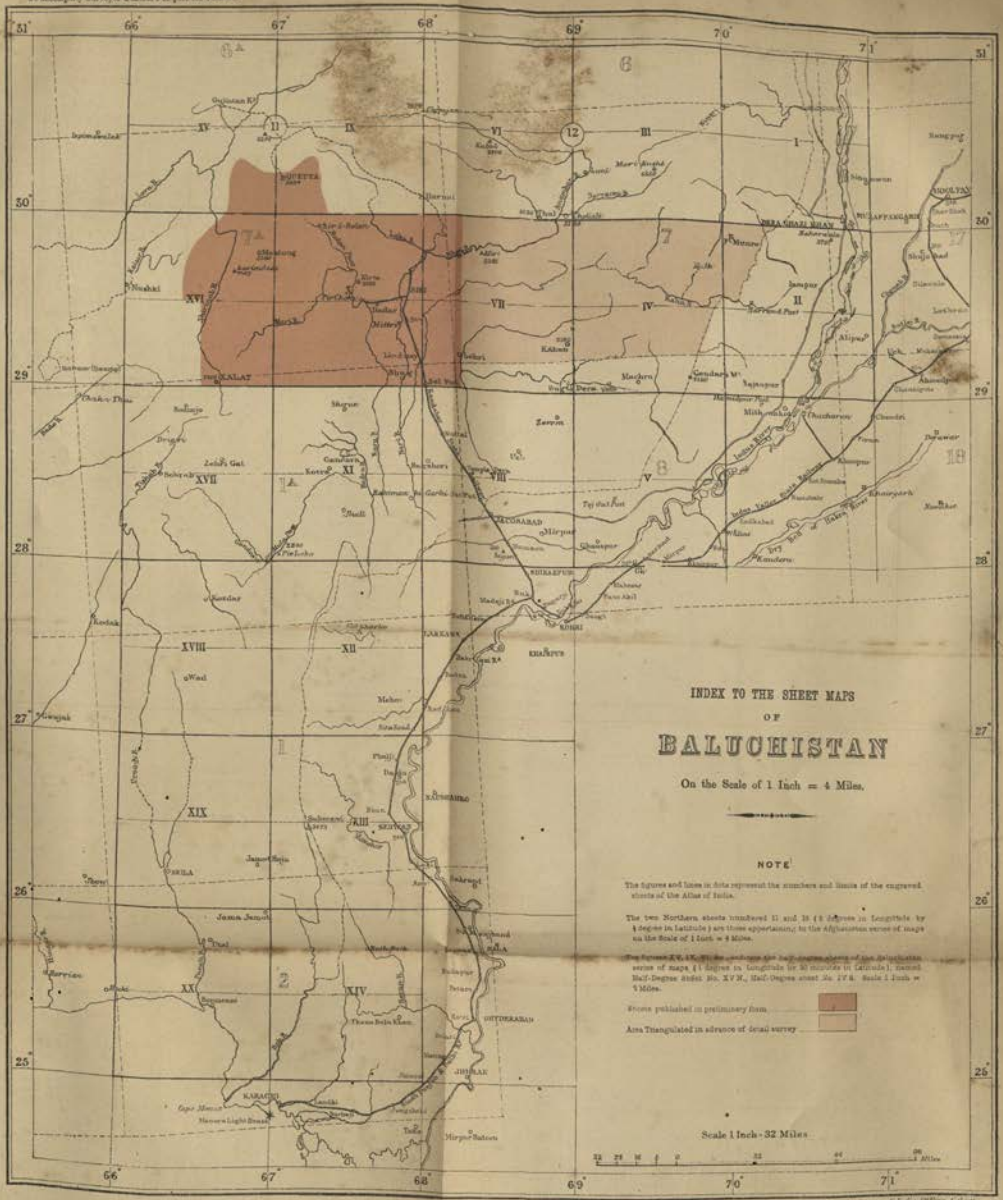


Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel G. C. DePree, S.C., Officiating Surveyor General of India.

Survey of India Offices, Calcutta, December 1883.

To accompany Surveyor General's Report for 1882-83.



Published under the direction of Colonel G. C. DePrée, R.E., Officiating Surveyor General of India.

Survey of India Office, Calcutta, December 1883.

Photozincographed at the Survey of India Offices, Calcutta.

on the scale of 3 inches to the mile, and again mapped on 2 sheets on the scale of 1 inch to the mile.

111. The officer in charge of the party acknowledges the hearty co-operation of Captain Petley, R.N., in charge of the Marine Survey, in all matters requiring the inter-dependent working of the two establishments.*

XV.—THE BALUCHISTAN SURVEY.

112. The survey of Baluchistan has been continued during the year under report by Major Beavan.

Personnel.

Major R. Beavan, Officiating Deputy Superintendent, 4th grade, in charge.
Mr. J. T. U. Coxen, Surveyor, 4th grade (on furlough from 28th May 1883).
Mr. P. White, Assistant Surveyor, 2nd grade (from 1st February 1883).
Mr. G. R. Copping, Assistant Surveyor, 2nd grade.
Sub-Surveyor Futteh Mahomed.
Ditto Abdul Rasul,
and two others.

The principal work of the season was triangulation, although a certain amount of topography was also executed on the $\frac{1}{2}$-inch scale, mainly with a view to filling up gaps and rendering the previously mapped area more complete.

The triangulation was commenced from stations of the Great Indus Series of the Great Trigonometrical Survey, and was carried over the Suliman range the Khetran country, and a portion of the Marri hills, a junction being then effected with the triangulation previously executed. It had been intended to extend it over the Bugti hills, but owing to tribal disturbances, this work had to be postponed, the country not being considered safe for detached survey parties. In lieu of the work thus interrupted, a series of triangles was commenced over the hill country lying between Kalat and the Kach Gandava plain.

113. The season's topography was carried on in the hilly country east of Kalat during the autumn, and again in the spring months; and during the cold months in the low country at the foot of the hills, and also in the low hilly country north of Sibi.

114. In all an area of 1,844 square miles of country was finally mapped during the season. Owing to the peculiar climatic conditions of Baluchistan, it is found impossible to employ the survey parties to advantage in any one portion of country throughout the season. In consequence of the intense heat during the autumn and spring in the low-lying country, it is only possible to employ the surveyors in the Katchi plain during the winter, and conversely the climate of the high grounds of Baluchistan is so rigorous in mid-winter, that if the weather should turn unfavourable no surveying is then possible at such high altitudes.

This necessitates a constant shifting of the *locale* of the survey operations which, though in a great measure inevitable, is very detrimental to a large out-turn of work.

115. A rapid reconnaissance was carried out by Mr. Coxen from Kalat to Nushki, with a view to selecting stations for an extension of the triangulation in that direction, and also of fixing with some accuracy, the position of Nushki, which had heretofore been doubtful. These objects were satisfactorily accomplished.

116. During the ensuing season the charge of this party will devolve on Major T. H. Holdich, R.E., Major Beavan being transferred to the charge of the Central India and Rajputana Survey. The strength of its *personnel* has been considerably increased in order to enable full advantage to be taken of the expedition about to be made by Sir R. Sandeman through the heart of Baluchistan. Two able officers, Lieutenants Talbot and Wahab, have been attached to the party for the express purpose of accompanying this expedition,

* Mr. Barrett thus reports of his assistants:—
"Mr. Pemberton has been of the greatest assistance in field and office. He exercises an intelligent control over the men placed under his orders * * *
"Mr. Kraal has worked satisfactorily throughout, and is especially to be commended for the energy with which he has assisted in bringing up arrears of mapping and typing.
"Mr. Smart has the reputation of being an able and willing assistant, but he unfortunately fell ill early in February, since which time his services have been entirely lost to the party.
"The native establishment generally has worked well. Sub-surveyors Mohan Singh, Sakhawat Hosain, Khurshed Hosein, Amjad Khan, and Dilawar Khan are deserving of special mention for the very satisfactory manner in which they have performed their duties."

which will, it is hoped, result in a large addition to our knowledge of the hitherto unexplored country in the neighbourhood of Kharan.

117. The anxiously hoped for expedition to the summits of the Takht-i-Suliman has received the sanction of the Government of India, and is now about to be undertaken. Major Holdich will himself accompany this, and it is believed that, if the weather should prove favourable, sufficient data will be obtained to enable a satisfactory map to be compiled of that large tract of country lying between the Gumal and Thal Chotiali routes.

118. Advantage will be taken of such opportunities as may occur during the season to complete our knowledge of the strip of trans-frontier territory lying between the British boundary and the crest of the Suliman range.

MOUZAWAR OR VILLAGE SURVEY.

XVI.—HISSAR DISTRICT, PUNJAB.

(No. 1 PARTY, REVENUE BRANCH).

119. This party having completed its former work in districts Dera Ismail Khan, Mozaffargarh, and Rawal Pindi, was directed to undertake district Hissar, the survey of which was ordered by letter No. 333S, dated 23rd August 1882, from E. C. Buck, Esq, C.S., Secretary to the Government of India, Revenue and Agricultural Department, to the address of the Secretary to the Government of the Punjab.

Personnel.

Lieutenant-Colonel D. Macdonald, Deputy Superintendent, 2nd grade, in charge.
Mr. W. S. Buttress, Surveyor, 3rd grade.
„ A. J Gibson „ 3rd „
„ G. Campbell, Assistant Surveyor, 1st grade.
„ J. C. Kelly „ „ 3rd „
26 Sub-Surveyors, and others.

120. The survey was originally intended to be purely topographical, on the scale of 2 inches to a mile, but after discussion, it was decided that village boundaries should be surveyed and areas of villages determined, so that the survey has partaken of the character of a mouzawar survey, although the 2-inch scale has been retained, which is different from the usual mouzawar scale of 4 inches. The work, however, has had a special feature in its having been required, under the orders of the Government of India, to include the determination by traverses of points (to be marked permanently) in the interior of the village lands, which are intended to form the basis of a cadastral survey of fields to be carried out hereafter by village *putwaris* under the supervision of the Settlement Department. This part of the work has no parallel in the case of the 4-inch mouzawar surveys, for which the basis of boundary traversing is generally found to be sufficient to meet the requirements of the 4-inch scale, but it is similar in character to the sub-traversing usually carried out for professional cadastral surveys, being only greater in extent in Hissar than in ordinary districts on account of the large size of the villages prevailing there. The permanent marking of the traverse stations in the interior of villages is also a special feature of this survey; it has a parallel in the marks which are being placed in the case of the British Burma cadastral surveys at selected stations where extensions of cultivation are likely to occur, but in Burma the marking has not been done in the same regular and systematic manner as in Hissar, and the plan, on account of the great facility it will afford for changes to be mapped, and for maps to be kept up to date generally, is well worthy of adoption for all cadastral surveys. The marks are placed over the village lands net-wise, at intervals of about half a mile. No maps are to be supplied to the Settlement Department, only copies of the traverse data, so as to allow of skeleton plots being prepared to any scale that may be required. The areas of villages are also to be furnished to the Settlement Department for the purpose of affording a check on the summation of field areas. Two sets of topographical maps are to be drawn for immediate publication, one set on the scale of two inches to a mile, shewing all the details as surveyed, for reproduction on the same scale; the second set, also on the scale of 2-inches to a mile, but drawn with the details somewhat generalized, for reduction to the 1-inch scale. Village boundaries will be shewn on both sets of maps.

INDEX MAP OF DISTRICT HISSAR

Scale 1 Inch = 8 Miles.

241 256 242 257 274 243 258 275 244 259 276 260 277 261 278

34 S.E. 48 S.W. 32 N.E. 48 N.W. 32 S.E. 40 S.W.

HISSAR

Rohtak Jhajjar Bahadurgarh Kanaud Narnaul Mahendragarh Rewari Gurgaon Ferozepur Jhirka Nuh Palwal Kosi Kalan Mathura Bharatpur Dholpur

NOTE.

The figures and lines in Ash represent the numbers and limits of the adjacent sheets of the Atlas of India.

Surveyed on Scale 4" = Mile in 1881-83.

Traversed in advance do.

The numerals (124) &c., indicate the sheets 30' x 15' on the Scale of 1 Inch = 1 Mile.

Published under the direction of Colonel T. H. Dallas, R.E., Officiating Surveyor General of India, at the Survey of India Offices, Calcutta, December 1885.

121. The party left its recess quarters at Murree early in October 1882, and field work was fairly commenced in Hissar on the 15th of the same month. Several traverse surveyors had been sent into the district a fortnight earlier to enable traverse plots for the topographers to be got ready quickly, and thus, as far as possible, to reduce the delay consequent on the want of the preliminary traversing, which is usually done a season in advance. The main body of the party remained in the field until the second week in April, and then returned to Murree, leaving a detatchment, consisting of one assistant-surveyor and ten sub-surveyors, to carry on throughout the year the extra work of sub-traversing for the settlement survey, as well as to supervise the permanent marking of the traverse stations.

122. The area in which all the operations required of the party have been completed, viz. village boundary traversing, plane-tabling and sub-traversing is 1,500 square miles; beyond which area, the village boundary traversing has been extended for 1,200 square miles and the plane-tabling for 161 square miles. The permanent marking of the stations has been nearly completed for the entire district.

123. With regard to the topography which has been executed, Colonel Macdonald reports:—

"Hissar is an exceptionally easy district for survey. * * * * * * * * * * * The plane-tablers surveyed everything that could be shewn on the scale. As no detail areas were required to be furnished, I directed "cultivation" and "lately thrown out of cultivation" to be included in one item under the head of "cultivation." With this sole exception the field sheets shew everything that is usually surveyed on the scale of 4 inches to a mile."

124. The plane-tabling has been tested by 197 linear miles of check survey. Azimuth observations have been taken at 106 traverse stations at an average interval of about 10 miles. A trigonometrical survey series—the Rahun Meridional—extends over the Hissar district, which afforded opportunities for connecting the measured traverses with 29 trigonometrical stations, and thus for eliminating the errors in the chain measurements. The average error in the chaining was found to be 2·89 feet per mile; in 22 cases of comparison the chaining being in excess, and in 12 cases being in defect.

125. Old masonry pillars were found standing at all the trijunctions of village boundaries at the commencement of the survey, but there were no marks at the intermediate bends, which were pointed out by the village *putwaris* who attended the surveyors. The village proprietors were also on the alert to see that their boundaries were being correctly surveyed, and the maps of a former settlement survey were available for reference, so as to ensure the old boundaries being adhered to. Regarding the marks which have been placed for the purposes of the settlement survey, Colonel Macdonald reports as follows:—

"The permanent marking of the theodolite stations proved a very troublesome and tedious job. A good deal of time was lost in determining the nature of the mark to be used, which should be both permanent and moderately cheap. Drainage tiles were suggested. They could not, however, be procured in the district, nor could they be imported at a reasonable rate. They were objectionable too, inasmuch as, after being buried for a few years, they are said to rot away and become amalgamated with the surrounding soil. Stone marks were not procurable in the district, and too expensive to import.

"Finally it was determined to use concrete blocks, in size 18″ × 6″ × 6″. These would be manufactured in the district, where lime was plentiful and cheap. Here, again, there was a difficulty, as no contractor would undertake the manufacture at anything like a reasonable rate. There was nothing for it but to manufacture the blocks under my own personal superintendence. This was done. We commenced work in December and by April we had close on 32,000 blocks ready for use.

"These blocks were buried at every theodolite station about 12″ deep and sticking 6″ above ground. When observations had been taken at a station, the block was covered up with loose earth to protect it, and a receipt was taken in every village from the *putwari* for the number of blocks used in his village. These concrete blocks will, I hope, prove satisfactory. From their nature they ought to last for several years, if left undisturbed.

"The total cost of permanently marking the stations will not exceed Rs. 13,000 for the whole district. The marks average eight to a square mile, or 28,320 for the whole district. (This is an approximate estimate). This would give the cost per square mile Rs. 3-10-9, and the cost per block 7 annas 4 pies."

126. The season's out-turn in Hissar has been mapped on 26 standard sized sections, which have been drawn in duplicate, one set for reproduction to scale, and one set for reduction to the 1-inch scale.

127. The sheets of the Murree and Kahuta tahsils are still unfinished, owing to the boundaries of the forest reserves being not yet all determined.

128. The party was inspected by the Officiating Surveyor-General during the month of October in its recess quarters at Murree. The excellent method of the Deputy Superintendent was found to result in accurate observations and computations on which to base a detail survey of ground, finally compiled in well-drawn, artistic sheets, creditable to all concerned. The hill surveys executed three years ago are remarkable for the topographical excellence that can be attained by a party of the Revenue Branch well commanded.*

XVII.—THANA DISTRICT, BOMBAY PRESIDENCY.

(No. 10 PARTY, REVENUE BRANCH.)

129. The field operations of this party, which commenced on 2nd December 1882, were carried on up to 17th May 1883 under the supervision of Major J. Hill, R.E., from which date, when Major Hill proceeded on leave, they were supervised for the remainder of the field season, which terminated on 5th June, by Mr. A. M. Lawson, Surveyor, 3rd grade. Major Hill returned from leave and relieved Mr. Lawson at Poona on 17th August.

Personnel.

Major J. Hill, R.E., Officiating Deputy Superintendent, 3rd grade, in charge up to 17th May 1883, and again from 18th August 1883.
Mr. A. M. Lawson, Surveyor, 3rd grade, in charge from 18th May to 17th August 1883.
Mr. J. Newland, Assistant Surveyor, 1st grade.
„ W. M. Kelly, „ „ 2nd „
„ R. R. Dickinson, „ „ 2nd „
19 Sub-Surveyors, and others.

130. The topographical survey of the Thana collectorate, which during the previous season was changed from a 2-inch to a 4-inch survey to meet the requirements of the Forest Department, has been continued on the same scale, and has included a careful survey of all the forest boundaries, provisional and final, in addition to the ordinary topographical details and boundaries of villages. The boundaries of the forests which are only provisional, and liable to change, have been surveyed with the villages, in order that the Forest Department may have fixed points of reference from which to lay down the final boundaries, when these are determined.

131. The area surveyed on the 4-inch scale in the Thana district is 663·3 square miles; besides which an area of 13·6 square miles has been surveyed in the Jawar State on the scale of 2 inches to a mile. Preparatory triangulation and traversing for next season have been extended, in addition to the above, over an area of 490 square miles. Triangulation alone has been done over a considerably larger area.

132. The portion of the district which has been under survey is situated in North Thana, and lies between the ghâts. The tract is thus described by Major Hill:—

"It is mountainous and covered with jungle, except along the sea-coast, where it is flat and marshy. The difference in altitude between the highest and lowest ground surveyed is 2,000 feet. This part of the country is notoriously unhealthy from the end of the rainy season until February, and, as usual, the party was crippled during the early portion of the field season through the prevalence of fever."

133. Major Hill also reports:—

"Some inconvenience was felt, specially in the survey of the provisional forest boundaries, through the occasional non-attendance of *telatis* and *patels*, who are required to point out

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* Colonel Macdonald reports as follows on his assistants:—
"Mr. Buttress * * * is a steady, hard-working, and painstaking assistant.
Messrs. Gibson, Campbell, and Kelly worked very steadily all the field season.
Amongst the native establishment, I beg specially to note the names of the following men, viz.—
Elahi Bux English writer, who is always ready and willing for any kind of work.
Ramtonoo Chuckerbutty, head computer.
Serajudin, Ramjus, and Myadhari, all excellent boundary surveyors
Ghulam Nabi, who turned out a large area of excellent plane-tabling."

village 'numbers' on the ground. One of the *mamlutdars* also was inclined to be obstructive, and was removed by the Collector to another taluka. My thanks are due to Mr. Mackenzie, the Collector, for the assistance he has given us, and for the arrangements he has kindly promised to make in order to facilitate our work next season."

134. All the village boundaries have been obtained from actual survey, but they have been subsequently compared with the boundaries shewn on the provincial survey maps. The comparison in the plain country is good, but on hilly ground the provincial maps are found to be very inaccurate.

135. The heights of 608 useful points, such as hill peaks, passes, junctions of rivers, &c., were determined trigonometrically. The traverse survey has determined the co-ordinate distances of 2,722 points, of which 306 are village trijunctions, and the remainder are marked with a + cut on stones. When the ground admitted of chaining, the plane-table sections were tested by check lines, of which 192 linear miles were measured; and where the ground was hilly, the plane-tables were put up at selected points and the accuracy of the survey tested by comparison with the ground.

136. Regarding the drawing of the 4-inch maps, all of which have to be printed on the original scale of the survey for the use of the Forest Department, Major Hill reports:—

"The number of 4-inch scale sections surveyed in a field season is so large when compared with the number which can be surveyed in the same time on the 2-inch or 1-inch scales that it would not be possible (with the present number of draftsmen in the party) to re-draw all the 4-inch scale sections during the recess, for reproduction, and to prepare reductions from them on the 2 inch scale for further reduction to the 1-inch scale It therefore became necessary to try if it would be possible, by taking certain precautions, to reproduce the original board-plan drawings, or a large proportion of them, and so avoid the danger of falling into arrears. In giving my detailed instructions to the party before taking the field, I promised that those whose board-plans are found to be capable of reproduction will receive greater credit than those whose field-work requires to be re-drawn in office I bring to your notice the following members of the party whose work has been found fit for reproduction, viz., Messrs. Dickinson and Kelly, Fyzulah Khan, Nathu Lall, Ramrao Yadom, Bullaji Luxman and Inayutulla Khan. On the whole 62·5 per cent. of the field-work of the party was found fit for reproduction, which for a first attempt is, I think, a very encouraging proportion."

137. The following is a statement of the maps which have been drawn during the recess:—

Maps on 4-inch scale for reproduction to scale.

16	Sections of	sheet No.	78.
8	Ditto	ditto	79.
2	Ditto	ditto	82.
8	Ditto	ditto	83.

Maps on 2-inch for reduction to 1-inch scale.

4	Sections of	sheet No.	79.
4	Ditto	ditto	83.

Major Hill reports as follows regarding the services of his assistants:—

"Mr. Lawson has for many years proved his efficiency as a good officer, and last year was no exception to the rule. * * * * Owing to the confidence placed in him, he was selected towards the close of the field season to hold charge of the party during my absence on privilege leave, and I found on my return from leave that he had conducted everything to my entire satisfaction.

"Mr. Newland has maintained the high reputation he has always enjoyed, of being an excellent worker and most valuable assistant. During the past field season I had to call upon him to make extra efforts to prepare work in a part of the district, in which, for sanitary reasons, I wish to mass the party at the commencement of next field season. He responded to the call and infused his spirit into those working with him, so that the work is now ready, and I hope that in consequence of his exertions the number of cases of sickness and death may be less than in recent seasons.

"Mr. Kelly has worked zealously and well both in field and office. * * * I have every reason to be well satisfied with him.

"Mr. Dickinson has worked well and steadily both in the field and in office. He is a good topographical surveyor and draftsman, and I am well satisfied with him."

Of the native establishment, Major Hill specially mentions Lingoji Patana, office assistant, Fyzulah Khan, Nathu Lall, Damodar Gopal, and Govind Janardan, sub-surveyors, but states that all the sub-surveyors, with one exception, have worked very well.

CADASTRAL OR FIELD SURVEY.

XVIII.—BALLIA AND BENARES DISTRICTS, NORTH-WEST PROVINCES.

(No. 4 PARTY, REVENUE BRANCH.)

138. This party resumed its cadastral operations in the Ballia district, and commenced similar operations in the Benares district on the 26th October 1882, continuing its field work up to 15th April 1883, when it returned to recess quarters at Naini-Tal.

Personnel.

Major W. Barron, S.C., Deputy Superintendent, 3rd grade, officiating in 2nd grade, in charge.
Mr. W. A. Wilson, Surveyor, 3rd grade.
„ H. T. Hanby, „ 4th „
„ W. C. Price, „ 4th „
„ S. O. Madras, Assistant Surveyor, 1st grade.
„ H. B. M. Drew „ „ 3rd „
„ L. F. Berkeley „ „ 3rd „
„ G. S. Willis „ „ 3rd „
appointed and joined on 25th February 1883.
„ E. F. Berkeley, Assistant Surveyor, 3rd grade, appointed and joined on 1st September 1883.
29 Sub-Surveyors and others.

Temporary Establishment.

183 Field Surveyors and others.

139. The party has also continued and completed the survey on the 4-inch scale of a line of river villages on the Ganges and Gogra rivers in districts Shahabad and Sarun of Bengal, lying opposite district Ballia, the purpose of which was explained in paragraph 130 of the last annual report. The survey has been carried as far as the junction of the united Ganges and Gogra rivers with the Sone river, and has thus extended considerably beyond the eastern limits of Ballia district. Boundaries of *mehals* have been surveyed as well as boundaries of villages.

140. The separate areas surveyed in the different districts and on the different scales are shewn in the following statement:—

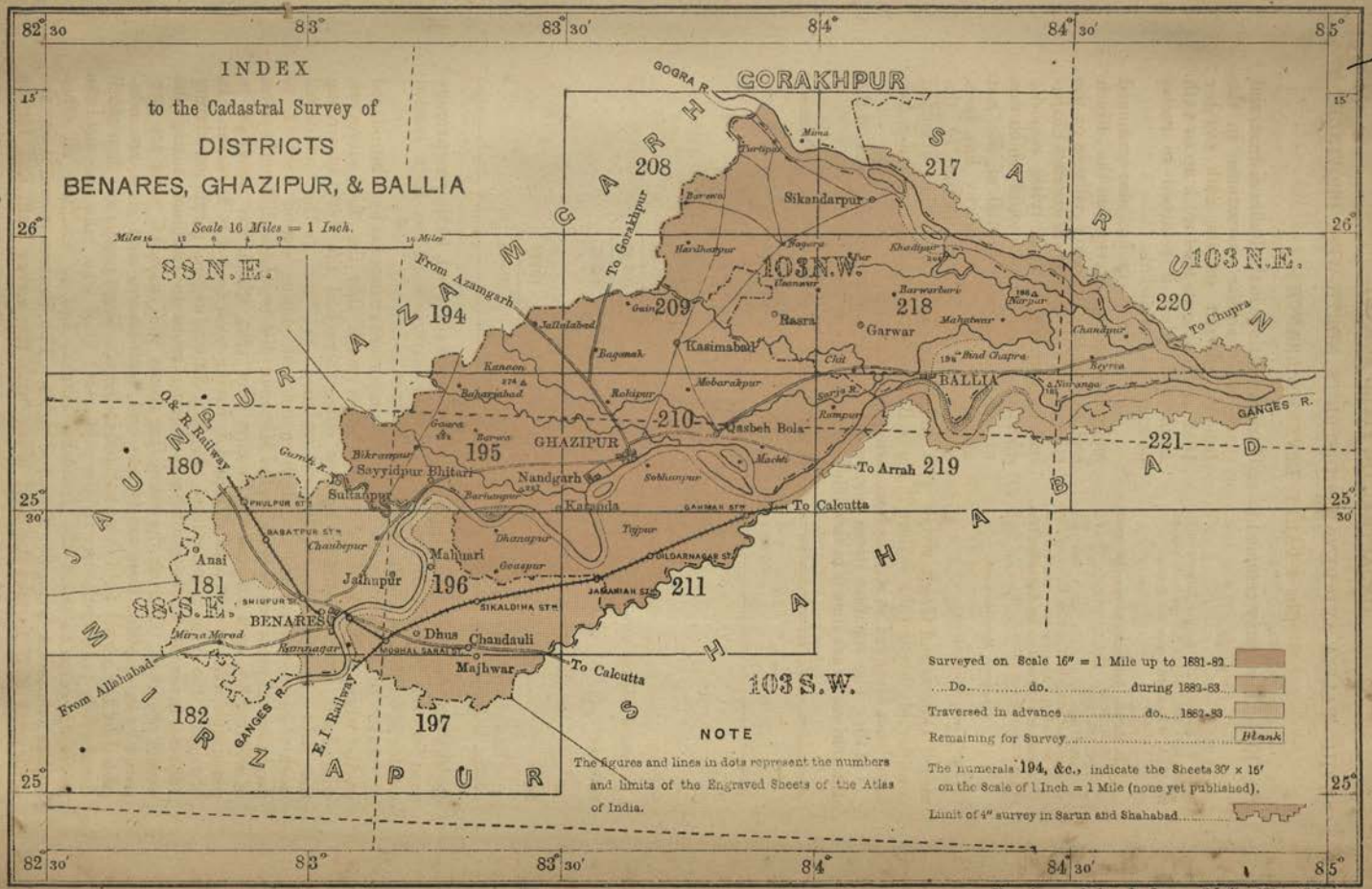
District.	Description and scale of survey.	Number of villages.	Area in square miles.	Remarks.
Ballia	Cadastral; 16 inches to a mile.	298	224·26	
Benares	Ditto ...	852	381·20	
Total of cadastral survey ...	.....	1,150	605·46	
Shahabad	Mauzawar; 4 inches to a mile.	268	262·67	
Sarun	Ditto ...	138	124·72	
Total of mauzawar survey ...	.....	406	327·39	

By the cadastral survey 4,77,358 fields have been surveyed, having an average area for each field of 0·81 acre. Preparatory traverse work has been carried out for 386 square miles in the Benares district.

141. In the Benares district, a very important change has been introduced in the work required of this party, in so much that the field surveyors, who have hitherto prepared maps only, have had the duty of writing the field registers (*khasras*) also assigned to them. The additional work of *khasra*-writing had already been assigned, during season 1881-82, to the cadastral party employed in the Mirzapur district, but a different system of working has been adopted for Benares from that which was described in paragraph 123 of last annual report as having been used for Mirzapur. In Mirzapur, the system introduced in 1881-82 and again continued during 1882-83, is for the *khasra*-writing and nothing more to be done during the season of survey. During the succeeding recess the *jamabandi* slips are prepared by compilation from the *khasras*, and both *khasras* and slips are completed by having the field areas entered in them. These papers are then considered ready to be made over to the settlement staff who take the field the following season to attest the *jamabandi* entries, and to complete all other papers connected with the record-of-rights. The Benares system is for the settlement staff to take the field along with the survey staff, and for the

No. 4 REV. PARTY.

N. W. PROVINCES SURVEY.



Photozincographed at the Survey of India Offices, Calcutta

Published under the direction of Colonel G. C. DePrée, S.C., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, December 1883.

two departments to work in co-operation, so that all the papers may be prepared during one season. Briefly stated, the system is:—*First*; the settlement staff supply the survey amins with such information as will enable the entries in the *khasras* regarding the shares of the proprietors and the occupancy rights of the cultivators to be correctly recorded. *Second*; the village *putwari* accompanies the amin during the survey, and writes a copy of the *khasra* exactly similar to the amin's copy (except that it is in the *Nagri* instead of in the Persian character), writing also concurrently in the *jamabandi* slips, which have been previously distributed to each cultivator, the numbers of the fields as they are surveyed. *Third*; the *putwari's* copy of the *khasra* and the *jamabandi* slips are at once made over to the settlement staff, with a manuscript tracing of the village map, to allow of any disputes being settled. *Fourth*; the computations of field areas are then carried out in the survey office, so as to complete the Persian copy of the *khasra*, which is then made over to the settlement staff, who in due course transcribe the areas on the *jamabandi* slips, and thus prepare these for final attestation. The exact procedure is explained in a joint memorandum drawn up by Mr. F. W. Porter, Settlement Officer, and Major W. Barron, Deputy Superintendent of Survey, which is given at page 88 of the Appendix.

142. His Honor the Lieutenant-Governor of the North-West Provinces conducted a personal inquiry with regard to the new system of survey at Benares, on the 11th January 1883, and after full investigation ordered the Benares system to be adopted in preference to the system followed in Mirzapur. The Secretary's letter expressing His Honor's approval is given at page 90 of the Appendix; and the reports of Major Barron and Mr. Porter on the results of the system, submitted as ordered after six months' trial, will also be found in the Appendix at pages 92 and 93. These reports shew conclusively that very great advantages have been derived from the new system of the joint inter-working of the settlement and survey staffs in carrying out the preparation of the record-of-rights in which both staffs are required to participate. The additional duty of *khasra*-writing has not added to the cost of the survey, while the settlement work has been done more expeditiously and at a cost bearing very favourable comparison with the rates in other districts worked under the old system.

143. During the recess, Major Barron has drawn up a compilation embodying the instructions issued to the Benares District Survey and settlement staffs for the combined operation of survey with the writing of *khasras* and *jamabandis*. These instructions have been printed in English and the vernacular at the Government Press, Allahabad, and they form a very complete and valuable guide to all survey parties working on the combined system in the North-West Provinces, while they will also serve as a basis for similar instructions to be framed for other provinces according to local variations of tenures and rights of occupancy.

144. The usual rigorous checks were carried out in all branches of the work. For checks on the angular work, observations for azimuth were taken at 73 stations; and for the check of the cadastral measurements, 1,470 linear miles of test lines were surveyed. Connections on two trigonometrical survey stations enabled the accuracy of the chaining of the traverses to be tested with the triangulation distances, the result shewing an average error of 1·6 foot per mile. The theodolite stations, when not on tri-junction stones, were all marked by pottery cylinders, sunk below the surface of the ground, except in and around the city of Benares, where stones have been used. The total number of stations marked is 17,465, and the cost of marking averaged 3½ annas per station.

145. Of district Ballia, 346 cadastral sheets have been surveyed, all of which, excepting 30 kept back on account of boundary disputes, have been sent to Calcutta to be printed. Of district Benares, 658 sheets have been surveyed, of which, as soon as they were drawn, manuscript tracings were furnished to the Settlement Officer to enable disputes to be adjusted and other inquiries made. The original sheets of district Benares will be corrected according to the settlement enquiries before they are printed.

146. There are 33 sheets of original 4-inch survey of the river villages in districts Ballia, Shahabad, and Sarun, of which 92 manuscript copies have

been prepared to be lodged in the collectorate offices of the districts concerned. These maps, however, are not yet finally complete, pending the result of a reference to the Board of Revenue, Lower Provinces, enquiring whether the lines of village boundaries according to two previous boundary surveys are required to be shewn on the present maps. The usual compilations of general maps on the 2-inch scale by reduction from the cadastral sheets have been brought up to date.

147. The recess office of the party was inspected at Naini-Tal during September 1883 by the Deputy Surveyor-General in charge, Revenue Branch, who highly commends the state of efficiency in which he found all branches of the office, as well as the care and ability displayed by Major Barron in the organization of the party generally. Major Barron's services have been temporarily lost to the department through his having been obliged to take leave to England for two years on account of ill health, and the occasion cannot be allowed to pass without a prominent record being given of the excellent work done by Major Barron in connection with cadastral surveys in the North-West Provinces during the past ten years.*

XIX.—MIRZAPUR AND GORAKHPUR DISTRICTS, NORTH-WEST PROVINCES.

(No. 5 PARTY, REVENUE BRANCH.)

Personnel.

Colonel F. C. Anderson, Deputy Superintendent, 1st grade, in charge.
Mr. C. W. Campbell, Surveyor, 1st grade.
„ E. J. Little „ 3rd „
„ T. P. Freeman, Assistant Surveyor, 1st grade, returned from leave without pay on 1st February 1883.
Mr. T. Shaw, Assistant Surveyor, 1st grade.
„ W. D. Corbett „ „ 1st „ resigned on 17th January 1883.
„ J. Murphy, Assistant Surveyor, 1st grade, transferred from No 2 Party from 1st July 1883.
„ E. P. S. Hill, Assistant Surveyor, 2nd grade.
„ O. D. Smart „ „ 3rd „
20 Sub-Surveyors and others.

Temporary Establishment.

233 field surveyors and others.

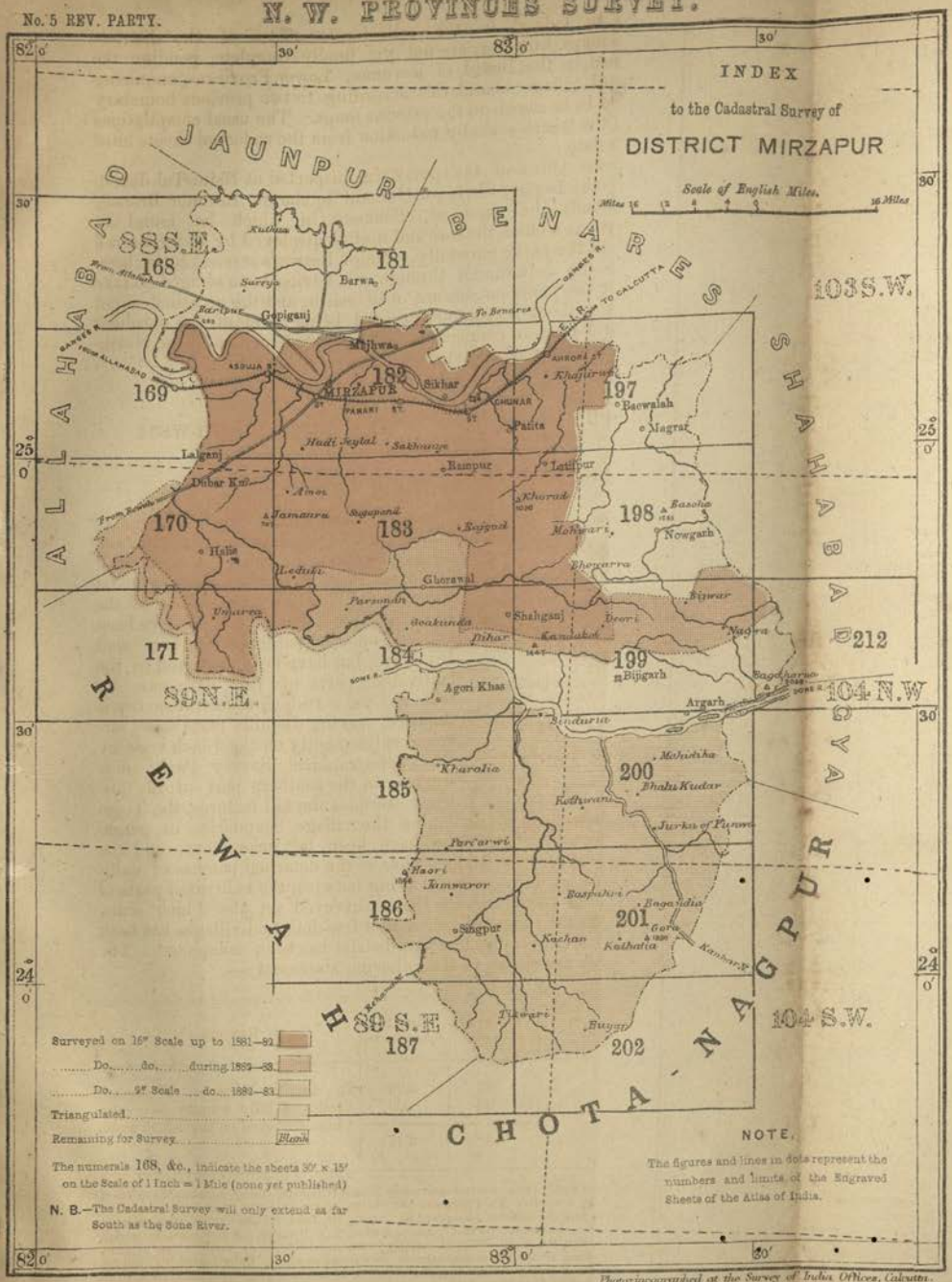
148. This party, under charge of Colonel F. C. Anderson, returned from recess quarters at Naini-Tal and resumed field work in the Mirzapur district on 1st November. The main operations of the season in the Mirzapur district have been carried on in parganas Barhar and Bijaigarh, but have been restricted to the cultivated parts of the parganas, for which alone a 16-inch cadastral survey is required, leaving the hilly parts to be surveyed subsequently on the 2-inch scale by the Topographical Survey Party now working in the southern part of the district. Besides the hill features, the Topographical Party will also have to determine the village boundaries in parganas Barhar and Bijaigarh, where these have been left incomplete; and the party may be required to furnish 16-inch plots of the detached patches of cultivation. A small area of hilly country lying between the cultivated parts of the district and the river boundary has been surveyed on the 2-inch scale. In the Tarai district, the cadastral survey of a few detached villages has been continued, and all the work required in that district has been completed. The areas of 16-inch survey are shewn in the following statement:—

District.	Number of villages.	Area in square miles.	Remarks.
Mirzapur	525	624	In district Mirzapur, 27 square miles of hilly country have also been surveyed on the 2-inch scale.
Tarai	23	23	
Total ...	548	647	

* Major Barron reports very highly on the services rendered by Messrs. Wilson and Hanby, in charge of sections of the establishment. He especially commends Mr. Price, who had charge of the section in Benares district engaged on the *khasra*-writing combined with the cadastral survey, and he thanks Mr. Price for the cordial co-operation he gave in introducing the new work. He also reports that "Messrs. Madras, L. P. Berkeley, and E. F. Berkeley worked heartily and well, as usual," and that Mr. G. S. Willis (a recently joined assistant) did his work "so as to merit approval" The following members of the native establishment are also commended by Major Barron, viz English and Persian Writer Ibu Hasan; Sub-Surveyors Jamaloodeen, Mahmood Bux, Abdool Jaleel, Bhowani Pershad; Draftsmen Meer Usjud Ali, Syudoodeen Ahmed; Computers Lalmohana Gungopadhya, Gunga Bishen, Sow Narain, Kanaya Lall; and Hospital Assistant Zakir Ally

No. 5 REV. PARTY.

N. W. PROVINCES SURVEY.

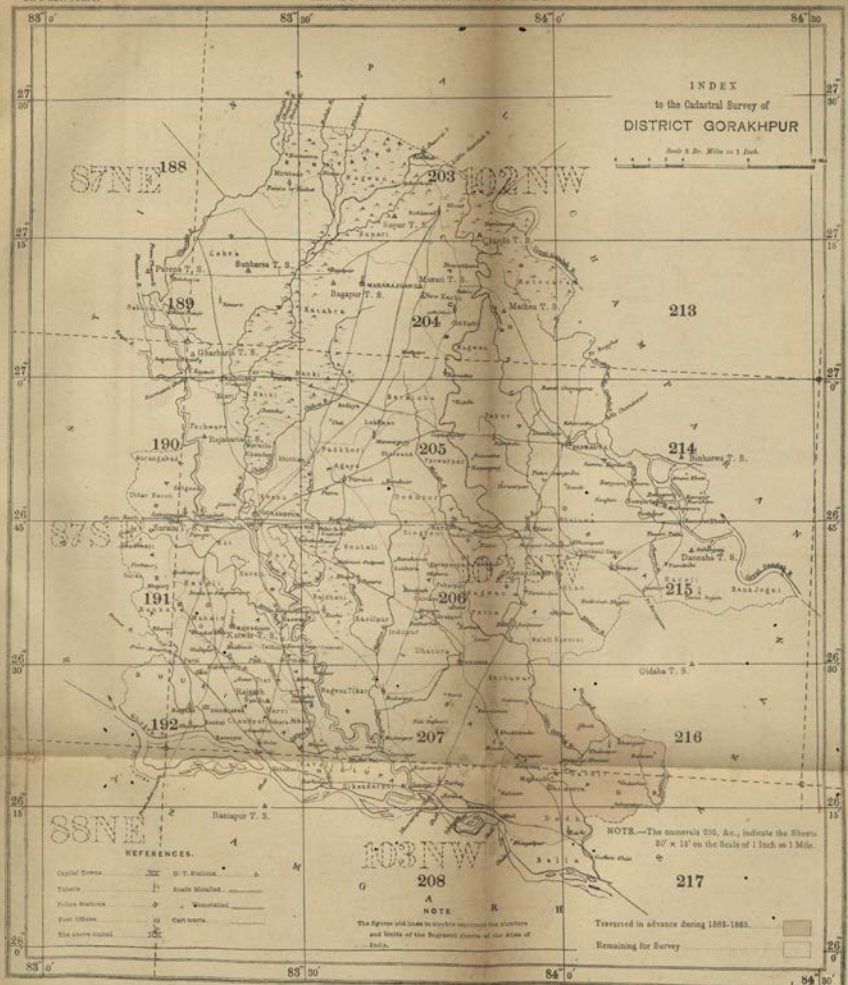


Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel G. C. DePrée, S.C., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, December 1883.

N. W. PROVINCES SURVEY.



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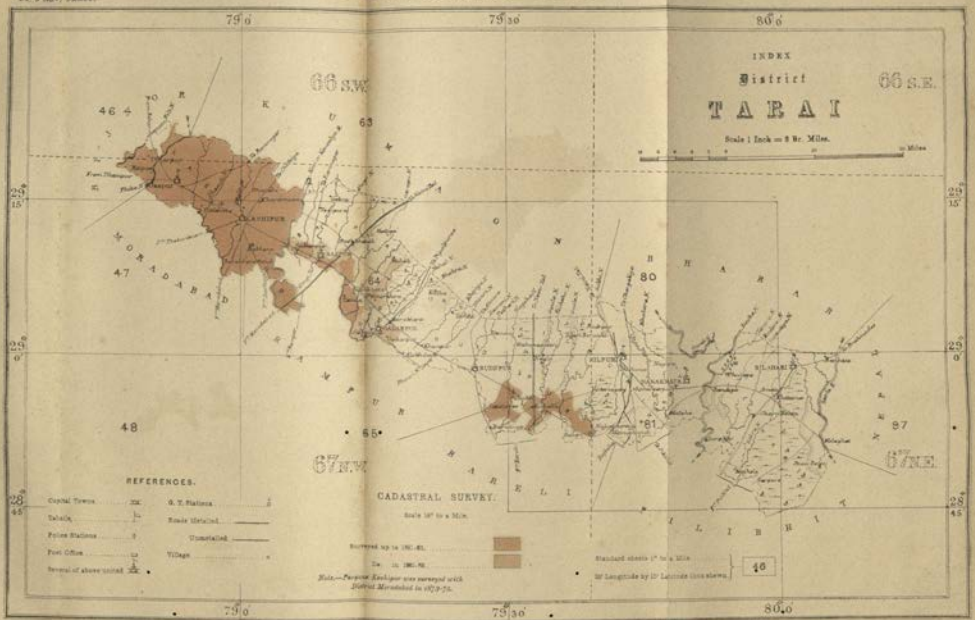
Survey of India Offices, Calcutta, December 1883.
Photolithographed at the Survey of India Offices, Calcutta.

No. 5 REV. PARTY.

N. W. PROVINCES SURVEY



Published under the direction of Colonel G. C. DePuis, R.C., Officiating Surveyor General of India, at the Survey of India Offices, Calcutta, January 1884.

149. The party has also broken ground in the Gorakhpur district, and has accomplished there 264 square miles (included in 774 villages) of preparatory village boundary traversing, in accordance with the Resolution of the Government of the North-West Provinces (communicated to the Government of India in letter No. 961, dated 17th April 1883), that the cadastral survey of that district is to be undertaken next after Mirzapur. The orders for the Gorakhpur survey having been issued late, the village boundary demarcations were not sufficiently advanced to admit of the traversing being begun before the middle of March, and the traversers had to be kept in the field till the end of June.

150. The additional work of writing the village *khasras* in the tract surveyed cadastrally in Mirzapur has again been assigned to the survey establishment, on the same system as is explained at paragraph 123 of the last Annual Report. The work was considerably hindered by the irregular distribution and the large size of some of the *putwari* circles, which rendered these officials incapable of giving much assistance to the surveyors in filling up the several columns of the *khasras*, and made it necessary for the *Nagri* copies of the *khasras* to be written up in the survey office as transcripts from the surveyors' *Urdu* copies, instead of being written at the time of the survey by the *putwaris* themselves. Nothing was done in the field besides writing the *khasras*, the preparation of the *jamabandi* slips being carried out afterwards in the office by compilation from the *khasras*, and the final work of attestation having still to be done during the following season by a settlement staff working with the survey *khasras* and compiled *jamabandi* slips.

151. It is said in paragraph 124 of the last Annual Report that the plan of having the *khasras* written simultaneously with the survey was introduced during the previous season as an experimental measure, and that the question of its further adoption would not be decided until the settlement part of the work had been done. There is no official information as to how far the experiment has been found to be successful, though Colonel Anderson has reported that he has been informed by the Settlement Officer that the survey-written *khasras* tested by him had been found to be remarkably free from error; but in the meantime the joint operation of survey and preparation of settlement records had been introduced on another system in the Benares district, and the Benares system, which is described at paragraphs 141 and 142 of this report has been approved by His Honor the Lieutenant-Governor for future adoption in other districts, in preference to the Mirzapur system. (*See* letter No. 961, dated 17th April 1883, from Officiating Secretary to the Government of the North-West Provinces and Oudh, to the Secretary to the Government of India, Revenue and Agricultural Department, page 90 of the Appendix.)

152. The Cadastral Survey has been tested by 207 linear miles of check surveys measured by European officers, and 774 miles by Native Inspectors. Azimuth observations were taken at six traverse stations in Mirzapur. The heights of 32 points in the Upraudh *tuppa* of Mirzapur—11 in the plains and 21 on the Kymore range of hills—have been determined by observations to and from Trigonometrical Survey stations. In Gorakhpur, azimuth observations were taken at 12 traverse stations, and the traverses have been connected with one Trigonometrical Survey station, the only one which was conveniently situated.

153. In Mirzapur, stones similar to those used in previous seasons have been embedded at 3,116 theodolite traverse stations, the stations, wherever practicable, having been fixed on the actual boundaries of villages, so that the stones may serve as boundary marks as well as survey marks. Regarding part of the Mirzapur district boundary, Colonel Anderson reports:—

"The southern boundary of the Upraudh *tuppa* of Mirzapur runs along the Rewah territory for about 87 miles, and is marked by 47 large stone pillars with English numerals cut on them, numbered consecutively from west to east. As these pillars were too far apart, I moved the Settlement Officer in 1880 to examine the frontier line, and in conjunction with an official from the Rewah Darbar, to interpret the boundary between the old stone pillars, and to demarcate it with the ordinary small slabs used for village boundary marks. This was accordingly done by the Magistrate and Collector, but, at his request, I refrained from embedding any of our theodolite station stones along the Rewah frontier, lest they should be mistaken for boundary marks, and give rise to unnecessary complications. The theodolite

stations along the Rewah territory have, consequently, not been marked by the triangular-shaped stones used everywhere else, but they have been defined by triangles cut on the surface of the sandstone rocks."

154. The cadastral survey in Mirzapur, done during the season, has been mapped on 899 sheets on the 16-inch scale, and the survey in the Tarai district on 37 sheets. Of these, 477 sheets have been sent to Calcutta to be printed, and 488 sheets of former seasons, which had been kept back on account of disputed boundaries, have been completed and sent down. Of Mirzapur, there are 81 sheets which cannot yet be printed, 65 being wanting in topography, and 16 forming parts of villages of which the plain portions only have been surveyed, the hill portions having been left to be added during the topographical survey. The boundaries of 16 villages are disputed, which delays the completion of 72 sheets. The entire area brought under cadastral survey in Mirzapur, falls on thirty 2-inch sections of eleven 1-inch standard maps; the reduction of the 16-inch topography has been very nearly completed. The sheets which include portions of country to be surveyed by the topographical party will not be published until they can be filled up to margin from the topographical survey.

155. Colonel Anderson retired from the Department on 31st October, after having been connected with it for over 31 years. Colonel Anderson has held charge of this party for 27 years, and has supervised the 4-inch surveys of districts Leia, Mozaffargarh, and Shahpur in the Punjab, and districts Partabgarh, Rai Bareilly, Sultanpur, Sitapur, Kheri, and Gonda in Oudh; and having been connected with the departmental cadastral surveys since their introduction in 1871-72, he has supervised cadastral operations in districts Muttra, Banda, and Mirzapur of the North-West Provinces. Colonel Anderson was appointed in 1860 one of two British Commissioners for the settlement and demarcation of the boundary between Oudh and the territory ceded to Nepal, and received the thanks of the Government of India for his services on that occasion. He has been retained for 16 months beyond the ordinary term of service in civil appointments at the special request of the Government of the North-West Provinces.*

156. The recess office of the party was inspected by the Deputy Surveyor-General in charge, Revenue Branch, at Naini-Tal, during September 1883.

XX.—HANTHAWADDY, PEGU, AND SHOAYGYEEN DISTRICTS, BRITISH BURMA.

(No. 2 PARTY, REVENUE BRANCH.)

Personnel.

Major J. R. McCullagh,' R.E., Deputy Superintendent, 4th grade, in charge.
Mr. E. J. Jackson, Assistant Superintendent, 1st grade, Officiating Deputy Superintendent, 4th grade.
" F. Grant, Surveyor, 1st grade.
" H. Dowman, Surveyor, 3rd grade, returned from deputation to Arakan Survey, 1st September 1883.
" D. A. King, Surveyor, 4th grade.
" J. McHatton, Assistant Surveyor, 1st grade.
" G. E. Parker " " 1st "
" J. Murphy " " 2nd grade, transferred to No. 5 Party, Revenue Branch, 2nd August 1883.
" B. M. Wilson, Assistant Surveyor, 2nd grade, transferred to head-quarters office, 1st November 1882.
" P. A. Peters, Assistant Surveyor, 2nd grade, transferred from Cachar Settlement Survey 27th February 1883.
28 Sub-Surveyors and others.

Temporary Establishment.

166 Field Surveyors and others.
2 Levelers.

157. This party, of which the strength is given in the margin, has remained throughout the year under charge of Major J. R. McCullagh, R.E. The traversing section took the field from head-quarters at Rangoon in the early part of November 1882; the cadastral sections went out on 1st December; and field work was continued throughout May, but with establishments reduced during that month according to the dates fixed for sending batches of men in fortnightly steamers back to India.

158. The cadastral work in the Hanthawaddy district has been carried on in the Hmawbee township, which has been completed, and in the Okkan circle of the Hlaing township, the only circle of this township which is

* Colonel Anderson, in reporting on the service of his assistants, refers to the long and meritorious service of Mr. C. W. Campbell, who retired on 31st October after a departmental service of 30 years, 27 years of which had been passed under Colonel Anderson's own orders. Mr. Little is praised for "his method of governing the large body of natives employed in a cadastral camp." Messrs. Freeman, Shaw, Hill, and Smart are all reported to have performed their respective duties quite satisfactorily.

INDEX TO THE

No. 2 REV. PARTY.

BRITISH BURMA CADASTRAL SURVEY.

DISTRICTS HANTHAWADDY, PEGU, SHWAY-GYIN & TOUNGOO.

INDEPENDENT
TOUNGOO
Kalaweng Bridge
Sheay-kyoo-hmo
Kamoon Myoung
Kyaut-Kaung
Kyaikto
Pattaway Gyaut
Kaukkyan
Wyay-gyin
SHWAY-GYIN
Gyaukkyan kyo
Kaukkyi
Myat-kyan
Pyaygan
Wingaday
Tsaing
Hmaw-kyan
Kyaik-kyan
Kyaikkyan
Kyaikkyan
Kyaikk

required to be surveyed cadastrally. In the Pegu district, which is a new district formed since last report from part of the Hanthawaddy district, the cadastral work has fallen in the cultivated parts of the Pegu and Pounglin townships, which parts only of these townships are to be surveyed cadastrally. The separate and total areas of cadastral survey are shewn in the following statement:—

Districts.	Townships.	Number of kwins.	Area in square miles.	Remarks.
Hanthawaddy ...	Hmawbee	15	22·98	
	Hlaing	57	94·83	
Pegu	Pegu	121	172·67	
	Pounglin	191	307·22	
	Total ...	384	597·70	

In addition to the above, boundary traversing has been carried on over 360 square miles in preparation for cadastral survey next season.

159. The revision of the previous season's maps, to bring them into accord with the settlement papers has been completed for the entire area which came under settlement, and the maps, as the revisions progressed, were sent up in batches to Calcutta to be printed. On this part of his work, Major McCullagh reports:—

"The revisions are due, as pointed out in my last report, to four causes, viz.—

(1) Errors of survey, that is, faulty measurements or incorrect inking up.

(2) Changes in the boundaries of fields and kwins.

(3) Imperfect or indistinct demarcation, especially of garden lands.

(4) Extensions of cultivation.

I have again tried to ascertain the percentage of errata under each of the above headings, and they are found to be very nearly as follows:—

Under head	(1)	...	...	...	...	10 per cent.
Ditto	(2)	...	...	...	...	50 „ „
Ditto	(3)	...	...	...	...	20 „ „
Ditto	(4)	...	...	...	...	20 „ „
				Total	...	100 „ „

The total represents the average percentage of fields revised and added to the original number over the whole 14 circles, but, as heretofore, the percentage of errata differs widely in different circles. * * *"

160. On the character of the country under survey, Major McCullagh reports as follows:—

"The area turned out * * * includes a good deal of garden land, always a source of trouble and anxiety to the surveyor, owing to imperfect demarcation and the difficulty of getting owners to point out their boundaries In the open parts the fields were very small, and in some places irregular in shape, which accounts for the somewhat smaller out-turn as compared with previous years."

Again—

"Then the Hmawbee circle was found to be very difficult, consisting of a confused mass of low hills and ravines covered with forest and interspersed with gardens."

161. Major McCullagh also reports:—

"The permanent demarcation has been carried out in the same manner as in previous years by means of burnt clay cylinders embedded at the theodolite stations, but this season the number of permanent marks has been largely increased. In the open country where long lines can be obtained, all or very nearly all the theodolite stations have been marked with cylinders, but in the jungle parts where the lines are short this has been done at every third or fourth station. The permanent marks embedded the previous year were found as a rule intact * * *."

162. The field survey was carefully examined and tested by the European officers and native inspectors, the amount of check surveys being 199 linear miles by the former and 304 miles by the latter. Azimuth observations as checks on the angular work of the traverses, were taken at 49 stations;

and several points of the Great Trigonometrical Survey enabled the chain measurements to be corrected according to triangulation distances. The number of fields in this season's work is greater than has ever been surveyed by this party, and amounts to 6,50,560, nearly 1½ lakhs over the number of last season. The average of each field is ·42 of an acre.

163. Regarding the employment of Burmans, Major McCullagh reports:—

"Again this year a large number of Burmans have been employed in various capacities, some as tindals of chainmen, the remainder as office hands and surveyors The usual drain on the party has been maintained for men to fill other situations in civil establishments, and as a natural consequence, only a very small proportion of the men can be considered as permanently belonging to the party. During the year, the number of Burmans employed in various situations (excluding tindals) comes up to 94, and of this number only 55 are now borne on the rolls."

164. The 16-inch sheets, 906 in number, of the area where the Settlement and Revision Survey operated, were all sent to Calcutta to be photo-zincographed between 8th February and 3rd July, after the revisions were inserted. The drawing of 788 new 16-inch sheets, surveyed during the season, has been completed and manuscript tracings have been given for the ensuing season's settlement operations. Of the general maps of the Hanthawaddy district, scale 2-inches to a mile, 15 sections have been completed and photo-zincographed during the year. A preliminary edition of the 16-inch maps, 19 in number, of the Rangoon town district has been printed for the purpose of aiding the investigations which have still to be made regarding the boundaries of very many of the town lots, before final maps can be published.

165. A small detachment from this party was again sent to Arakan, under charge of Mr. H. Dowman. The programme of the season included (1) the permanent demarcation of the waste-land grants left unfinished the previous year, (2) the continuation of the revision of the boundaries of these tracts after settlement enquiry, and (3) the survey of the Myinbin oil-field. The first part of the programme was carried out, but as there was no Settlement Officer appointed this year, only 27 grants, which had been dealt with the previous year, could be revised. Towards the end of January, Mr. Dowman proceeded to Kyoukhpyu to survey the oil-field, and was appointed to exercise the powers of a Demarcation Officer, as the boundaries of the lands assigned to each existing oil-well had to be demarcated. A topographical survey was also required of the whole oil-bearing tract. The demarcation proved a tedious operation, for the boundary of each well was to be the circumference of a circle having a radius of 100 yards. By the end of May, when the operations were stopped, 35 oil-bearing grants had been demarcated and surveyed in boundary, of which number, 32 grants had also been surveyed topographically. The land occupied by the refinery belonging to the "Boronga Oil Company" near Kyoukhpyu was also surveyed.

166. This party also sent a small detachment under Mr. McHatton, Assistant Surveyor, to Tavoy to survey a portion of the Nat-ya-doung hill and to mark out blocks on the same for grants to intending settlers. The detachment was absent during November and December 1882.

167. Major McCullagh continues to exercise a general superintendence over the Government survey school maintained at Rangoon, and he reports that this school occasions a great tax on his time.

168. Two squads of levelers have again been attached to this party, and a report on their work will be found with the other leveling operations of the department at page 52.*

169. The office of the party at Rangoon was inspected by the Deputy Surveyor-General in charge of the Revenue Branch during May 1883, and the results of the inspection are stated to be satisfactory.

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* Major McCullagh reports on the European officers attached to his party as follows:—

"Mr. Jackson, Assistant Superintendent, has throughout been active in carrying on the duties of the boundary camp, and in overcoming the numerous difficulties he had to contend against.

Messrs. Grant and King, Surveyors in charge of cadastral camps, have, as usual, conducted the field survey in a most satisfactory manner.

Mr. Dowman, Surveyor, carried out the troublesome operations in Arakan with great tact and good judgment.

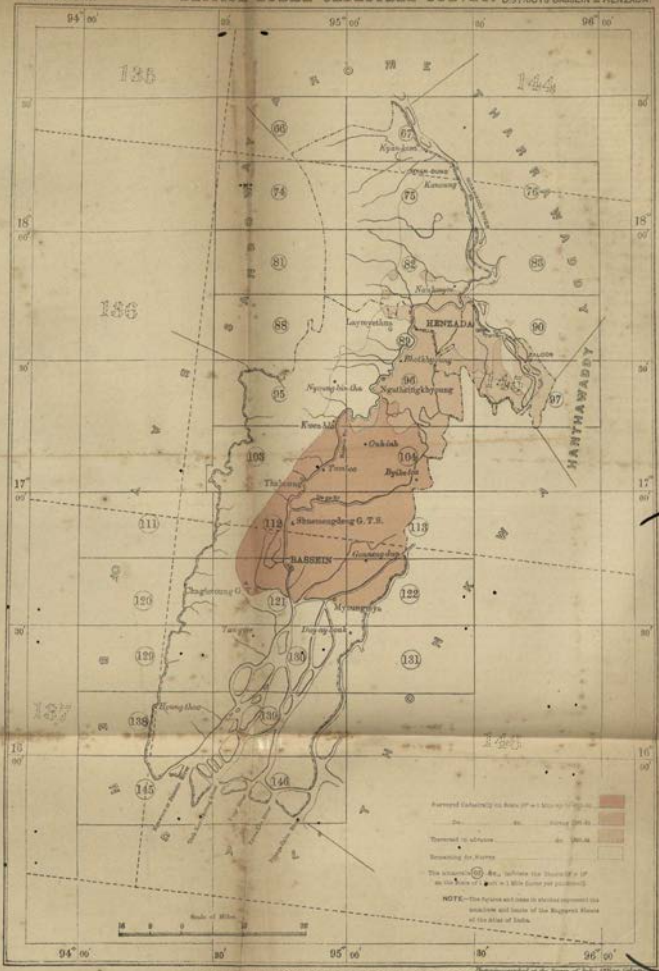
Mr. McHatton, Assistant Surveyor, has again proved himself to be a very painstaking, careful, and thoroughly reliable officer.

Messrs. Parker, Murphy, and Peters, Assistant Surveyors, though employed in somewhat less responsible positions, have one and all performed their duties to my entire satisfaction".

INDEX TO THE

No. 3 REV. PART.

BRITISH BURMA CADASTRAL SURVEY. DISTRICTS BASSEIN & HENZADA.



Published under the direction of Colonel G. C. DePree, R.E., Officiating Surveyor General of India,
Survey of India Office, Calcutta, December 1892.

XXI.—BASSEIN AND HENZADA DISTRICTS, BRITISH BURMA.
(No. 8 PARTY, REVENUE BRANCH.)

170. This party was under charge of Major W. H. Wilkins during the field season, but as Major Wilkins had intimated that his health was indifferent and likely to necessitate his proceeding on leave, Major H. S. Hutchinson was attached to the party as Assistant Superintendent and to be successor to Major Wilkins. Major Hutchinson received charge of the party on 29th May 1883.

Personnel.

Major W. H. Wilkins, Deputy Superintendent, 3rd grade, in charge up to 28th May 1883. On furlough to Europe from 8th June 1883.
Major H. S. Hutchinson, Deputy Superintendent, 4th grade, transferred from head-quarters office, Calcutta, on the 26th November 1882. In charge from 29th May 1883.
Mr. H. R Littlewood, Surveyor, 3rd grade.
" R. B. Smart, Officiating " 4th "
" T. H. Dunne, " " 4th "
" W. H. Penrose, Assistant " 1st "
" C. W. J. Ford, " " 2nd "
" W. H. D. Ewing, " " 3rd "
29 Sub-Surveyors and others.

Temporary Establishment.

144 Field Surveyors and others.

171. The party took the field on the arrival of the establishments from India on 5th and 11th December, and field work was continued throughout May, with a reduced establishment after the 15th, on which date the first batch of men was sent back to India.

172. Cadastral operations were commenced in the Bassein district, and about the middle of the season were extended into the Henzada district. The separate areas of the different townships which have been under survey in each district and the total area are given in the following statement:—

District.	Township.	Number of kwins.	Area in square miles.	Remarks.
Bassein	Kyone-pyaw, Yay-gyee, Laymyet-hna	191	441·46	
Henzada	Zaloon ...	75	176·92	
Total ...	.....	266	618·38	

In addition to the above, boundary-traversing has been extended over 465 square miles in preparation for next season's cadastral survey.

173. Some parts of the country are said to have been very difficult for survey on account of the many small detached portions of rice cultivation or plantain gardens, which existed in the jungle, involving much line-clearing in order to fix the positions of the isolated patches. The separate areas of the cultivated and jungle lands are—

Cultivation*	278	square miles.
Waste land	340	" "

the former being somewhat greater than last year. In the cultivation there are 5,31,194 fields—nearly two lakhs in excess of last year—having an average area of ·33 of an acre.

174. The revision survey in the area surveyed during the previous year to bring the maps in accord with the Settlement papers of the year following, proved a very heavy part of the season's work, requiring the undivided attention of about one-sixth part of the whole establishment during the field season. About two-thirds of the revisions are said to have been due to extensions in the cultivation. Revision operations were required to be carried on in 430 kwins out of the 480 which had been surveyed.

175. This season all the theodolite traverse stations, instead of certain selected stations, have been marked with pottery tiles by the survey establishment during the progress of the traverse work.

176. The survey of the fields and other details has been carefully tested by check surveys, of which 212 linear miles were measured by European officers and 586 miles by Native inspectors. The Assistant Superintendent and two Assistant Surveyors were also constantly in the field moving about among the field surveyors. The angular work of the traverses has been checked by observations for azimuth at 104 stations, and the chain measurements have been brought into accord with the triangulation distances between four stations of the Great Trigonometrical Survey, with which connections have been made.

177. The Burmans in the party, who have been employed chiefly as cadastral field surveyors but a few also as theodolite traversers, are reported to have done good work, though small in quantity. Their intelligence and good education are highly spoken of, but as formerly, it is said that they cannot be depended upon for steady work. A considerable number of Burmans have been trained for the supplementary survey; and the Bassein survey school class was taken into the field with the party for the purpose of being instructed in practical work.

178. A small detachment of the party has been employed in surveying the town of Bassein on the scale of 64 inches to a mile, at the expense of the municipality. The surveyors have been associated with the Settlement Officer in making enquiries regarding the town lots about which there had been very imperfect information; and a new register of the lots, shewing areas, has been prepared in connection with the survey. The boundaries of the lots have also been closely demarcated.

179. All the cadastral maps of the previous season have been completed in accordance with the revisions consequent on settlement examination, and they have also all been printed, and copies issued to the supplementary survey, having been sent up to Calcutta in batches during the recess. The cadastral maps of the present season, 706 in number, have all been drawn, and manuscript tracings with field area statements supplied to the Settlement Officer. The general maps on the 2-inch scale, obtained by reduction from the 16-inch maps, have nearly been brought up to date, and three have been sent up to Calcutta to be printed.*

180. The party was inspected in camp at Bassein and Henzada during May 1883 by the Deputy Surveyor-General in charge of the Revenue Branch, who reports that he was satisfied with the care which was being bestowed by the supervising officers to ensure accuracy in all parts of the work.

XXII.—THARAWADDY AND PROME DISTRICTS, BRITISH BURMA.

(No. 7 PARTY, REVENUE BRANCH.)

Personnel.

Mr. H. B. Talbot, Officiating Deputy Superintendent, 3rd grade, in charge.
Mr. F. W. Kelly, Assistant Superintendent, 1st grade, transferred from the head-quarters office, Calcutta, from 1st March 1883.
Mr. W. R. Vyall, Surveyor, 3rd grade, on furlough from 1st August 1883.
Mr G. W. Jarbo, Assistant Surveyor, 1st grade.
„ J. R. Scott „ „ 1st „
„ J. S. Swiney, „ „ 1st „
„ E. J. Martin, „ „ 1st „
transferred to the head-quarter's office, Calcutta, from 1st December 1882.
Mr. A. W. Smart, Assistant Surveyor, 2nd grade.
„ D. J Collins, „ „ 2nd „
25 Sub-Surveyors, &c.

Temporary Establishment.

100 Field Surveyors and others.

181. Field operations were resumed by this party under Mr. H. B. Talbot on 1st December 1882, and were continued up to 31st May 1883. The area remaining for cadastral survey in district Tharawaddy has been completed during the season, and the survey has been extended into the adjoining district of Prome.

182. The following is a statement prepared by Mr. Talbot of the detail and total areas surveyed in the two districts:—

Districts.	Number of kwins.	Number of fields.	Average size of fields.	Cultivation.	Waste.	Forest reserves.	Total Area.	
							Acres.	Square miles.
			Acres.	Acres.	Acres.	Acres.		
Tharawaddy	69	131,023	0·22	28,920	97,294	8,076	133,630	208·80
Prome	334	782,130	0·32	221,927	133,469	.....	390,395	609·98
Total ...	403	913,153	.....	250,187	235,762	8,076	524,025	818·75

* Major Hutchinson reports very highly of Mr. Littlewood's judicious management of the large section of the establishment placed under his charge. Mr. Smart is reported to have supervised his section zealously and ably; and Mr. Dunne, who supervised the revision work, is said to have done so with much method and care. Messrs. Penrose, Ford, and Ewing are reported to have given satisfaction; the two last named being said to have specially distinguished themselves by working exceedingly hard.

No. 7 REV. PARTY.

BRITISH BURMA SURVEY.

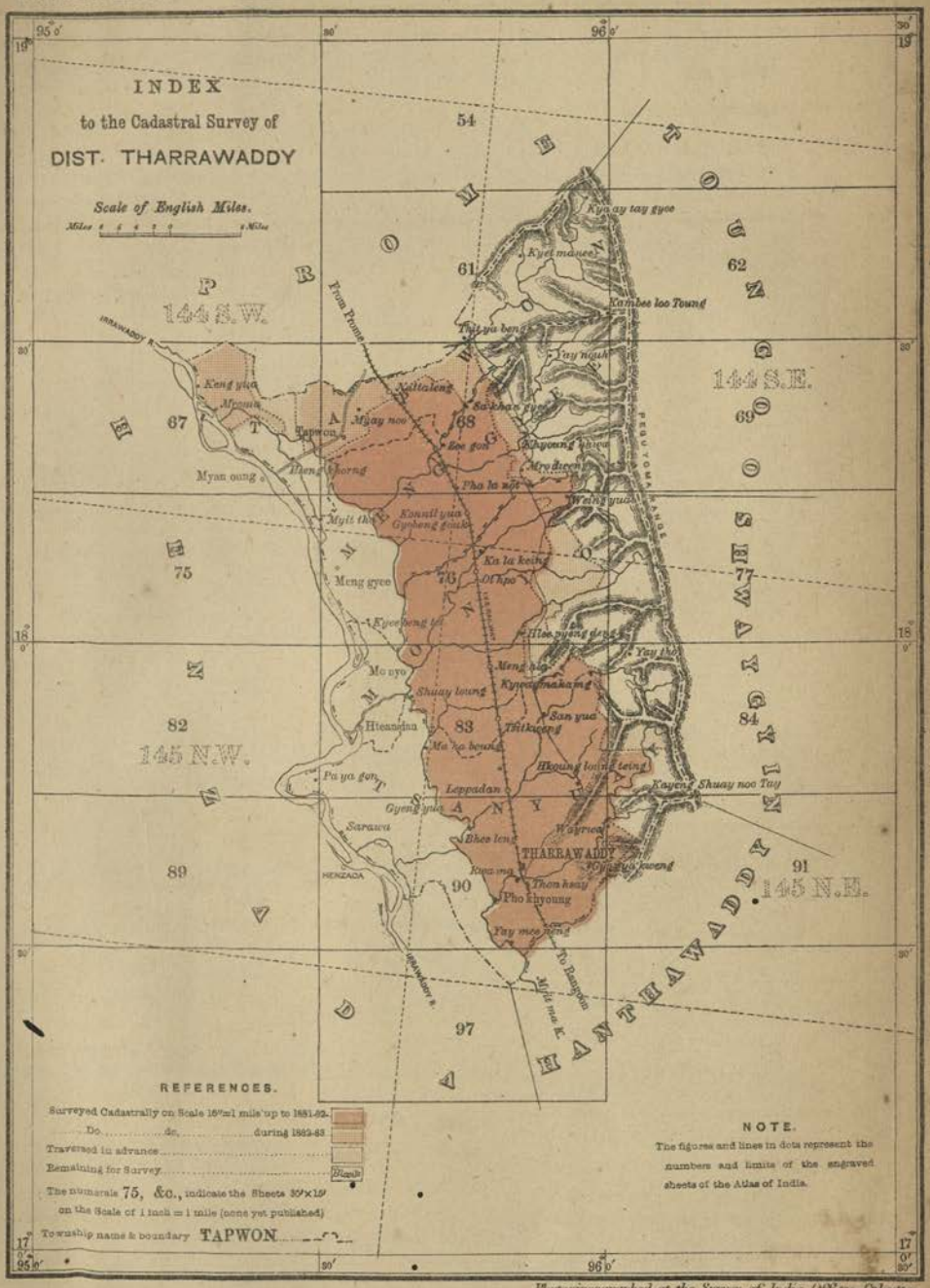
Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel G. C. DePrée, S.C., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, December 1883.

No. 7 REV. PARTY.

BRITISH BURMA SURVEY.



Photozincographed at the Survey of India Offices, Calcutta.

Published under the direction of Colonel G. C. Du Prée, S.C., *Officiating Surveyor General of India,*

Survey of India Offices, Calcutta, December 1883.

183. The preparatory traversing has been done for 54 square miles remaining for cadastral survey in district Prome; and the town of Prome has also been traversed in preparation for a survey on the scale of 64 inches to a mile.

184. The survey of changes and extensions of cultivation in the area surveyed during the previous season for the purpose of bringing the maps and area records into accord with the settlement papers was done in the usual manner, and the maps were sent to Calcutta to be printed from time to time during the recess season.

185. Permanent marks, consisting of pottery cylinders, sunk flush with the surface of the ground, have been put down at kwin boundary traverse stations, and at other selected interior traverse stations, the same as in former years. The usual check surveys have been measured as a test on the accuracy of the cadastral survey, their aggregate length being 654 miles by European assistants and 877 miles by Native surveyors. Azimuth observations were taken at 20 traverse stations. The traverses have been connected with four Trigonometrical Survey stations, and the comparisons instituted between measured and triangulation distances shew that the chaining has been generally 4 feet per mile in defect.

186. Mr. Talbot writes as follows regarding the country surveyed:—

"The area returned as waste, both in Tharawaddy and Prome, is not in separate blocks, but is mixed up with the cultivation. In some parts, especially in Shwaydoung and Mahathaman townships, the fields were found to be very minute, ranging from ·01 to less than ·25 of an acre, and scattered among patches of waste and jungle from which it required considerable trouble and time to separate them."

187. About his Burman field surveyors, Mr. Talbot reports:—

"During the season 13 Burmans were employed as surveyors, and they generally maintained their reputation as careful and accurate plane-tablers, under strict supervision and check. They are not, however, superior in accuracy to the Hindustani amins, whom they do not approach in rapidity, as the following comparison will shew:—

	Acres.
"Daily average out-turn by Burmans	17
"Ditto ditto Hindustanis	32

"In addition to the Burmans actually employed in the field as amins, 73 lads were trained to the use of the plane-table and optical square, and many of them were engaged during the recess in tracing maps and calculating areas. As remarked last year, the Burman lads evince no desire to take permanent employment in the Survey Department, their sole object evidently being to use it as a stepping-stone to obtain Myaydaing Thoogyeeships. The survey, then, is a large training school for lads who render a short service and pass out just as they become useful."

188. The season's out-turn of cadastral survey has been mapped in 946 sheets, of which 217 are in Tharawaddy, and 729 in Prome. Tracings of nearly all of these with field area statements have been handed over to the Settlement Officer in time for his operations of the following year. Of the 19 sheets on the 2-inch scale, which include all the area surveyed cadastrally in Tharawaddy, 6 have been completed, and the remaining 13 are well advanced.*

189. The field office of the party was inspected by the Deputy Surveyor-General in charge of the Revenue Branch in camp, in the Prome district during May 1883. Colonel Sconce has much pleasure in testifying to the high state of efficiency he found existing in the party, which he considers to be mainly due to Mr. Talbot's personal devotion to his duties.

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* Mr. Talbot reports on his assistants as follows:—
"Mr. F. W. Reily, Assistant Superintendent, * * * joined me on the 6th March, and was put in charge of a cadastral camp, which he has managed to my entire satisfaction. * *
"Messrs G. W. Jarbo, J. R. Scott, J. S. Swiney, and A. W. Smart are hard-working, intelligent, and excellent assistants. * * * Mr. D. J. Collins continues to improve, and has done well throughout the season."
Of the Native establishment, the following are specially commended, viz. Baikishun, Sub-Surveyor; Sashi Bhusan Ghosal, Computer; Mr. La Rive and Issan Chander Ghosal, Writers.

XXIII—SURVEYS BY THE DARJEELING PARTY.

190. The arrangements for the season under notice were made by Captain Harman, who had held charge of the party for several years. He was now, however, so dangerously ill that it became necessary for him to take leave, and accordingly Colonel Tanner relieved him of the charge on 1st November 1882.

Personnel.

Lieutenant-Colonel H. C. B. Tanner, Deputy Superintendent, 3rd grade, in charge from 1st November 1882.
Captain H. J. Harman, R E., Assistant Superintendent, 1st grade, in charge to 1st November 1882.
E. C. Ryall, Esq., Assistant Superintendent, 1st grade.
Mr. D. Atkinson, Surveyor, 1st grade.
„ W. J. O'Sullivan „ 4th „
„ W Robert, Assistant „ 1st „
„ W. C. G. Barckley „ „ 1st „
„ R. W. Senior „ „ 3rd „
Sub-Surveyor Sahai Din.
„ Ram Saran.
„ Goberdhan Chatterjee,
and others.

191. The operations of the season were carried on in three different localities, *i.e.*—

(*a*) In Darjeeling district—revisionary survey.
(*b*) From the river Koosee to Tirbeni on the Gunduck river—Nepal Boundary Survey.
(*c*) Independent Sikkim—survey of.

192. The Darjeeling Revisionary Survey was carried on, as before, under the immediate charge of Mr. Ryall, assisted by Messrs. Robert and Barckley; it was commenced in the previous year, and has now been completed. The work presents an accurate topographical survey of the district west of the Teesta, and also includes, by incoporation, correction, and addition, boundaries of estates previously surveyed or now determined. The contouring has been carried on with appreciable nicety at 1,000 feet intervals of height where the country was sufficiently open to admit of using the water-level, and between these leveled lines, eye-contours were run at every 50 feet of height. But on other areas covered with dense forest, or otherwise inaccessible to the water-level, the country was studded with points of which the heights were determined trigonometrically, so that on the average 11 heights to the square mile were thus fixed, and with these as obligatory points, the required 50-feet contours were found. In all, 175 linear miles were water-levelled and over 1,500 heights determined trigonometrically, besides some 700 barometrical heights; also 373 square miles were topographically surveyed on the 2-inch scale, and 60 square miles were triangulated. The survey is both complete and accurate, and reflects credit on Mr. Ryall by whom it has been conducted, and to a large extent also executed.* Suitable stations have been selected by Colonel Tanner, and are in course of being protected for the use of posterity, and the boundary between Darjeeling and Nepal has also been marked by the erection of permanent pillars.

193. The Nepal Boundary Survey includes that portion of the line in the plains between the Koosee river in the Bhágalpur district, where the survey of 1875 under Captain Samuells ended, and Biknatori in Chumparun district on the eastern termination of the Sumesar range; also, in continuation of this portion, that part of the boundary westward from Biknatori along the watershed of the range to Tirbeni Ghát on the Gunduk river. The plain section is 271 miles in length; it has been traversed and drawn on the 4-inch scale, including about a quarter of a mile on either side of the line surveyed in detail in order to promote ready identification of localities, and will be published in 33 sheets. The work has also brought to light six instances of altered or disputed boundary which are under settlement. In addition, it was found that the whole line required restoration, more or less, in respect to pillars and posts, as well as running demarcation by ditch and bank; this work will be executed in 1883-84, and at the same time monoliths will be set up at the trijunction points (*i.e.*, points *on the line* common to two villages) where Colonel Tanner's useful suggestion to erect such marks has been approved of by the Government of Bengal. With regard to the hill section from Biknatori to Tirbeni Ghát, of about 50 miles in length, the portion being some distance removed from previous triangulation required in the first place to be connected trigonometrically; further the tract proved unhealthy and otherwise difficult, and in view of utilizing the opportunity for sketching northward, only a preliminary reconnaissance on the $\frac{1}{4}$ inch scale was made of the range. This, however, discloses such a

* Mr. Ryall reports of his assistants:—"My thanks are due to Messrs. Robert and Barckley."

complete want of resemblance in the only and ancient delineations forthcoming, that the survey of this important section has been sanctioned for execution on the 1-inch scale in 1883-84.

194. The more pressing requirements of the operations mentioned, left Colonel Tanner but little time or means for also prosecuting the survey of Sikkim, on which work, it will be remembered, Mr. Robert in his expedition of 1881-82 made such excellent progress. Colonel Tanner, however, contrived to make two short excursions in person, by which he not only added to the survey, but detected and strengthened weak points, and otherwise obtained information calculated to promote the more comprehensive expedition to be undertaken immediately after the closing of the rains. This expedition he was unable to conduct in person, other important requisitions for survey operations having meanwhile arisen; he therefore despatched Mr. Robert on the duty, having provided him with the men and material he had intended for his own use, and otherwise giving him directions for the arduous task in view. Mr. Robert performed his part gallantly and skilfully, and maintaining his course with praiseworthy perseverance and courage, in regions moreover always bitterly inclement and frequently desolate, he returned to Darjeeling on the 16th December, having completed the survey of Sikkim in all but a small and accessible portion. Particulars of his work cannot be stated at present.

195. In connection with the operations in Sikkim and along the Nepal boundary, every advantage has been taken of the opportunity to sketch visible portions of the latter country, and otherwise to establish within it a numerous series of points on which to build up details already known, or that may hereafter be acquired. Geographical information of kinds is to a certain extent not wanting, but hitherto it has been impossible to join together different lines of travels or isolated sketches with any degree of accuracy, because such contributions all began and ended in *unknown* localities. The want thus indicated will be exactly met by what may be called the Skeleton map of Nepal, now in view, but progress in this direction is greatly retarded by the well-known haze in which that country is usually enveloped, as described by Colonel Tanner in his narrative, so that it is only at intervals that the required points are visible from British territory. Notwithstanding, sensible progress has already been made as to points; besides a belt of Eastern Nepal has been sketched from Sikkim, and the delineation of the basin of the Gunduk has also been secured. It will be seen that the value of a map of the kind contemplated. cannot be overrated.*

196. The map of the revisionary survey of Darjeeling on the 2-inch scale is in four sheets, which require the services of a draftsman for only some two months to pass them for publication. The map of Independent Sikkim is on the $\frac{1}{2}$-inch scale and in five sheets; these are advanced so far as the materials had been reduced: the publication will exhibit no small area of *terra incognita*, a knowledge of which has long been a desideratum. The 33 sheets of the Nepal Boundary Survey will be ready for photo-zincography not long after the disputed boundaries have been settled.

The party was inspected by Mr. Hennessey, Officiating Deputy Surveyor-General, in charge Trigonometrical Branch.

197. In the year under review the Survey of India experienced a lamentable loss in the death of Captain Henry John Harman, R.E., who for about eight years had held charge of the Darjeeling Party in its present and previous localities. He was appointed to the Great Trigonometrical Survey (now a portion of the Survey of India) in June 1872, when he had been about six months in India; and, after a few weeks passed in the computing office, was attached to the survey of Kumaun and Garhwál, where he took a creditable share in those topographical operations. A twelvemonth later he was placed in charge of a party (No. 1 Extra) in Southern India (Bangalore), and successfully conducted that portion of the main or trunk line of Indian levels from Karwar *viâ* Bellari to Guti, a distance of over 300 miles; he also made preliminary tidal measurements at Karwar for sea-level. From September 1874 to May 1878 he carried on the triangulation of the Assam valley from Sibságar to Sadiya. In this interval he also

* Lieutenant-Colonel Tanner reports that Messrs. Atkinson, O'Sullivan, and Senior have rendered every satisfaction.

accompanied Major Godwin Austen on the Daphla expedition, and with Captain Woodthorpe surveyed the Miri hills: besides, he measured the discharges of several tributaries of the Brahmaputra, in connection with the enquiry as to the identity of the Sanpo and Dihang rivers. In 1878 his party was transferred to Darjeeling, where he continued to the end of his official career—1st November 1882—conducting several operations which can only be briefly indicated here. They included local surveys on various scales, some short explorations by natives he had trained, and the survey of Independent Sikkim and outlying regions. This last work unhappily held so powerful a charm for him, that neither its hardships, anxieties, and exactions, nor its bitter rigors and desolation could deter him from undertaking explorations even after the fatal warning he received at the Donkia pass, where his feet became frozen, so that portions of them died, and his lungs contracted disease which eventuated in his death. Kind hearted and generous, he was readily followed; cheerful and sanguine, he was enthusiastic to rashness; fertile in ideas, he rose equal to his difficulties, and like other Englishmen who have helped their country to her eminence, he knew not when he stood vanquished. He died at Florence, April 14th 1883, hardly 33 years old.

XXIV.—GEOGRAPHICAL.

1.—NORTHERN AFGHANISTAN, &c., SOUTH-EASTERN AFGHANISTAN AND KAFIRISTAN.

198. A large area of mapping was executed in this tract during the year under report, Major Holdich and his enterprising assistants, European and native, having largely added to our information.

199. A general map of Afghanistan on the scale of $\frac{1}{4}$ inch = 1 mile is in process of compilation in sheets of uniform size of 2 degrees of longitude by 1 degree of latitude, for which an index has been arranged, so as to embrace all the country brought under the cognizance of our surveyors on the north, and extending as far south as the frontier of Baluchistan.

200. In addition, it is in contemplation to complete a series of maps on double the scale of the above, or $\frac{1}{2}$ inch = 1 mile, depicting the frontier lands from the north, about Peshawar, to Fort Munro on the south, where it will combine in an uniform manner with the sheets of the regular survey of Baluchistan now in progress under Major Holdich. This survey will be executed with the plane-table by skilled surveyors, and will be of a degree of accuracy compatible with the unfavourable conditions imposed on the surveyors in being limited to a range of positions attainable by them when not permitted to encamp beyond the British Frontier. The Frontier Survey has now been completed from the north as far south as the valley of the Gumal, and it is expected that the valleys of the Draband, Choudwan, Rimak, Vihowa, and others will be mapped from their entrance on the valley of the Indus up to the dominating mountain ridges forming the northern and southern extensions of the Takht-i-Suliman. Westward of this, the country can be surveyed by distant sketching only, supplemented by route surveys brought in by the native explorers.

201. On the north, a tract of country in the Jowaki hills was left unsurveyed during the military expedition of 1877-78. This was undertaken by Munshi Esuf Sharif, a sub-surveyor of well known capacity, and carried out with admirable tact and courage He prevailed on the maliks to escort him into the interior of that inaccessible nest of hills, but after reaching his ground and obtaining the desired look over the valleys he wished to survey, he was told that he must return. He returned, therefore, and recommenced his regular work within the British boundary by way of throwing the Jowakis off the scent, watched his opportunity, and taking a few men only with him, again advanced to the desired vantage ground, and in two days completed all the survey that was wanted, before the maliks again appeared on the scene. These he persuaded to take him to Musadarra itself, but here he was surrounded by a furious crowd, and shots even were fired at his party, luckily without effect. However, undaunted he managed to set up his plane-table and fixed the position of Musadarra, the only feature remaining to complete all the survey.

To accompany Surveyor General's Report for 1881-82.

INDEX TO THE SHEET MAPS OF AFGHANISTAN

On the Scale of 1 Inch = 4 Miles.

NOTE

The figures and lines in this map represent the numbers and limits of the engraved sheets of the Atlas of India.

The numerals 1, 2, 3, 4, &c., indicate the 1-degree sheets of the Afghanistan series of Sheet 41 degrees in longitude by two degrees in latitude). Scale 1 Inch = 4 Miles.

Sheets published on the Scale of 1" = 4 Miles. Preliminary Edition.

Do. in course of publication.

Scale 1 Inch = 32 Miles.

Published under the direction of Colonel G. C. Duffin, R.E., Officiating Surveyor General of India, Survey of India Office, Calcutta, December 1882.

Photozincographed at the Survey of India Office, Calcutta.

Further to the west, Mr. Claudius, having disguised himself, and relying on the protection of the chiefs, without companions or servants of any kind, but equipped with a small plane-table unscrewed and in pieces, advanced up the valley of Bar Marai and ascended a lofty peak commanding the Orakzai Tirah. Fraternising with the people, he obtained all the opportunities he required, and retraced his steps across the border. Here he prepared for a second expedition under similar conditions to the last. He advanced up the Bizoti valley and crossed into that of the Bara river, plane-tabling, as he went, portions of the imperfectly known Sipai country, and actually ascended to within 150 yards of the summit of the Maulagárh range, when he found that his disguise was well known, and he was angrily turned back by armed tribes, who fired at his party. Disappointed at failing to obtain a view of the country below the Hindu-Kush but with a good crop of new survey, he returned into British territory. The topography of the border was thus completed as far south as Bannu. The tract extending to the Gumal valley was taken in hand by Mr. McNair, who having ascended the Kafir-Kot hill in 1881-82 so as to complete the country of the Waziris, next took in hand successively, the valleys of the Kaitu-Kuram, the Baran, the Tochi, and the Kaisor, the highlands of the Batanis, and the mountain range overlooking the plains as far as the Girni-Sir peak. It will be the business of Major Holdich and his surveyors to continue this frontier survey during the ensuing field season. Under the conditions imposed of never encamping outside of our border, the physical endurance of the surveyors is extremely taxed; to take a long march over-night so as to ascend a difficult hill at early morning, to trudge all day over rugged hills and barren plains, and then to retrace his steps to his tents at night, and this, day after day, requires a man of exceptional mettle.

202. Behind this strip of Frontier Survey has been built up, bit by bit, continuous maps obtained by native explorers, working with the simplest instruments, measuring distances by pacing, but all adjusted, checked, and fitted into the more complete work done with the plane-table. These exploration maps are on one-half the scale of the others. In this way a well trained but comparative novice, who is known under the *nom de guerre* of "the Hakim" has brought in an exploration of the Tochi valley as far westward as the valleys of Shawal, Birmal, and Sarobi, crossing the watershed of the Gumal and Tochi rivers, and fixing the position of the Kotanni pass, the watershed of streams flowing into the Ghazni valley. This exploration occupied some two months. Westward again, the well known explorer "the Syud" traversed the direct road between Bannu and Ghazni, going over his old ground as far as Sarafza. At Ghazni his disguise was betrayed, and he was seized and imprisoned, but eventually was sent to Kabul and taken before the Amir, who allowed him to return to British territory by way of the Khyber route. Unfortunately some of his original documents were lost, but he brings invaluable information regarding this direct route from India to Ghazni. The veteran "the Bozdar" was not actively employed during the season, but his intimate knowledge of the country and people, allowed of his compiling geographical information; and opportunities were forthcoming for confirming the accuracy of his work of 1881-82, when he explored the affluents of the Gumal, the Sharan, and the Kandil rivers.

203. About the close of the ordinary field season, or in March 1883, "the Syud" again started on his explorations, but this time in the direction of Kafiristan. He was, however, accompanied by the adventurous surveyor Mr. W. W. McNair, who, equipped with a plane-table of an extremely portable pattern, and carried on by his indomitable pluck and extraordinary tact, penetrated into that hitherto inaccessible country. Passing by Dir over the Lohori pass, and thence to Chitral, the European surveyor leaving his companion amongst his Mahomedan friends, boldly entered Kafiristan and ascended a high range on the west, dominating the greater part of that country; from thence he ascended the Hindu-Kush, and obtained a view into Badakshan on the north, returned to Chitral, and eventually emerged into British territory by the known route of the Mastuj, Yasin, and Gilgit valleys, and Srinagar. During this expedition the European surveyor mapped the country in regular order with the plane-table and observations taken to peaks already determined from a distance by the Survey of India, and the native ran a continuous route

survey based upon the fixings of his companion. The combined results surpass in completeness the efforts of any other explorers.

2.—EXPLORATIONS IN GREAT TIBET AND MONGOLIA.

204. These explorations were designed by and executed under the orders of General J. T. Walker, C.B., R.E., F.R.S., who was present in India and welcomed the return of A— K— after an absence extending from April 1878 to December 1882. General Walker's preliminary and general sketch of the explorations has already appeared in the report for 1881-82, and is considered sufficient introduction to the subject pending detailed account of the operations now almost ready for submission: meanwhile, as the sketch map in three sheets, and Index to the same, are given in this report, it becomes necessary to add here a few introductory remarks regarding these publications.

205. In accordance with General Walker's instructions A— K—'s operations were to be reduced and prepared for publication under Mr. Hennessey's supervision. The work was accordingly taken in hand without delay, and has been fully completed to the extent of the sheets attached.

206. These sheets were prepared as usual from A— K—'s measurements in paces and bearings, subject to sectional checks from his latitude observations, of which he diligently secured an ample amount, having observed at no less than 22 stations: each of these stations was thus fixed in latitude, and in longitude by the point on the parallel where the length from the last fixed station cut that parallel; proceeding in this manner, the circuit from Lhása northwards to Gobi and back *viâ* Dárchendo and Sáma to Chetáng (a point previously fixed) was laid down, with the result that it re-entered by only $1\frac{1}{3}$ miles in latitude and $1\frac{3}{4}$ miles in longitude, an accordance highly creditable to A— K—'s skill and exactness: each of these latitude stations is indicated on the sketch map by the letter λ. Besides the above test, A— K— agrees in the position of Jún by Prejevalsky (*first* published), in that of Dárchendo by the Jesuit Fathers, in the route from the last named place to Lhamdun Giachug (40 miles south of Báthang) by Gill, in the position of Sáma by Wilcox, and in that of the Archa Cho lake by a previous explorer, all of which is highly satisfactory. That A— K— places the large town of Sachu, the most northern point visited, about 2° west of Prejevalsky's position, was only to be expected, for the latter has adopted the erroneous value of longitude by the Jesuit Fathers (1711), and in fact in his *second* publication, Prejevalsky has unfortunately thrown the whole of the results he *first* published into error by making the longitude of Sachu agree with that of 1711: this there can be little doubt from the evidence of A— K—'s work is wrong to the extent indicated, (2°).

207. In addition to observations for latitude, A— K—, fixed the heights of 69 places by boiling-point observations: all these heights are given in the sketch. He also observed air temperatures at several places for some consecutive days, which reveal at least an intensity of cold on some occasions quite unexpected, as will be seen in the account now approaching completion.

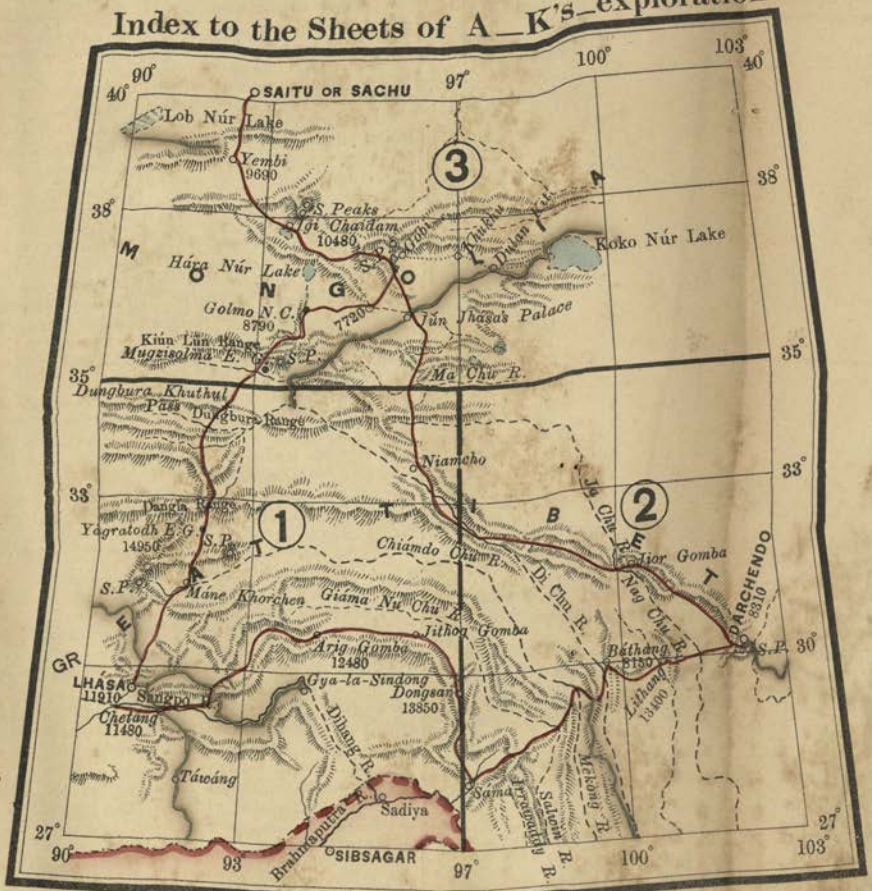
208. Leaving the sketch map, for the present, to advance its own claims on the attention of geographers, this much at least may be now said in its behalf: it establishes the long disputed identity between the Sánpo and Brahmaputra rivers, and thus assigns for the latter an origin so far distant as the Manasarowar lakes; and it defines the watersheds of the Brahmaputra and the Irrawaddy, north and east of Assam, to an extent that was highly desirable.

3.—SURVEYS IN DARDISTAN AND ON THE KISHANGANGA.

209. The detachment consisting of Ahmed Ali Khan, sub-surveyor, and a small native establishment was employed mostly on completing the survey of Chilás (Dardistan), besides such features in Darel and Tangir as were visible, and part of the required supplemental topography in the basin of the Kishanganga: the work was carried on under the immediate orders successively, of Mr. Hennessey and Mr. Cole.

210. As explained in the previous report, Dardistan, though rendered inaccessible to surveyors by the opposition of the rulers of the country, is still susceptible of accurate surveying, as pointed out originally by Colonel

Index to the Sheets of A_K's_exploration



The route of explorer A—— K——. is colored red Routes of other explorers introduced here are colored green. S. P. signifies snowy peak. E. G. signifies encamping ground. N. C. signifies nomad camp.

Scale 1 inch = 140 miles

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, January 1884.

C. Dyers, Photo. C. G. Gillenbach, Zincog.

Published under the direction of Colonel G. C. DePrée, R.C., *Offg. Surveyor General of India.*

Tanner; because it juts into the province of Kashmir, and is enclosed on three sides by a range of mountains, horse-shoe in shape, which command a view of the entire valley excepting the waters of the Indus itself, and a strip along either bank, of perhaps a mile in width. Advantage being taken of these peculiarities, a complete survey has now been effected of Chilás, including determinations of all the passes which lead to it.

211. Profiting by the experience of the previous season, Ahmed Ali Khan reached his ground in Kághán even before the winter's snows had sufficiently melted. In due course he followed the horse-shoe watershed, by visiting different points on it, right round to Hatu Pír, and then crossing the Indus at Bunji, resumed his progress along the Indus-Gilghit watershed, to the Bariben pass, where he completed the required survey of Dardistan. The passes fixed in all, across the watershed, are as follow:—

	Pass.	Position determined.	Height determined.
On Indus-Kághán watershed.	Sepat	By Revenue Survey	
	Chichirgáh	Ditto	
	Babusar	Ditto	13,600 (1883)
On Indus-Kishanganga watershed.	Kamukdori	„ Kashmir detachment 1882	13,400 (1882)
	Between Kamukdori and Barai	1883	15,000 (1883)
	Barai (or Bunar)	1882	
On Indus-Astor watershed.	Thosho	1881	17,700 (1883)
	Mazeno	1881	
	Chorgali (*a*)	1883	
	Do. (*b*)...	1883	
	Satiabe	1883.	
On Indus-Gilghit water-shed.	Kani	1883	
	Luthu	1883	12,900 (1883)
	Two between Damachal and Husharai Valleys	1883	
	Between Amges and Bashu Valleys ...	1883	
	Matere	1883	14,600 (1883)
	Malpat	1883	
	Bariben	1881	14,200 (1883)
	Kinejut	1881	

He has also fixed the positions of all villages and forts in the country, and besides minor glaciers he discovered one nearly eight miles in length in the Diamerai Valley, some 22 miles west (nearly) of Astor.

212. Ahmed Ali Khan's survey of Dardistan on the $\frac{1}{4}$-inch scale includes an area of about 2,000 square miles, which will no longer be a blank on the map, as hitherto; besides this, he has also made some progress in the supplementary topography of the Kishanganga basin. Further description of his operations, and the tracts of country he surveyed must be postponed, pending reduction of the work. His out-turn is highly creditable to him, the more so that to secure it he had to endure a good deal of hardship, including getting through the night, as he best could on several occasions, without a tent, on ground buried in snow and at heights from 14,000 to 16,000 feet above the sea.

TIDAL AND LEVELING OPERATIONS.

XXV.—THE TIDAL OPERATIONS.

213. The recording of tidal curves by self-registration, their reduction, and the publication of tide prediction tables have continued in progress satisfactorily; at first under Major Rogers, who also made a considerable tour of inspection, and subsequently from 19th April, on his return from furlough, under Major Baird, who initiated the work, and has conducted it with ability and assiduity.

Personnel.

Major M. W. Rogers, R.E., Offg. Deputy Superintendent, 3rd grade, in charge up to 18th April 1883.
Major A. W. Baird, R.E.; Offg. Deputy Superintendent, 3rd grade, in charge from 19th April 1883.
Mr. T. H. Kendell, Surveyor, 4th grade.
„ E. J. Connor, Assistant Surveyor, 1st grade, Officiating Surveyor.
Sub-Surveyor Dhondu Venayek.

214. During the year, tidal observations have been carried on at the following stations:—

Aden.	Negapatam.	Dublat (Saugor Island).
Kurrachee.	Madras.	Rangoon.
Bombay.	Vizagapatam.	Moulmein.
Kárwár.	False Point.	Amherst.
Beypore.	Kidderpore.	Port Blair.
Pámban.	Diamond Harbour.	

215. It will be seen that Pámban Observatory has ceased to be operative: this was directly induced by severe weather, which more or less injured the observatory and necessitated the removal of the instruments for a considerable time; also, the observations were now in their fifth year, and in view of sanction, since received, for establishing observatories at Colombo and Galle, the observatory and equipment were more urgently needed in Ceylon. The observatory at Kárwár being no longer required, was also dismantled; and that at Elephant Point (Burma) was not operative, because the site proved dangerous for occupation, and removal to a safer locality became necessary. The self-registering instruments for the observatory which His Highness the Thákur of Bháunagar intends to establish are not as yet at work; but meanwhile eye-readings on a graduated staff were taken at Kathiwadar for a period of 375 days by a subordinate to Mr. Proctor Sims, Engineer to the Bháunagar State, and these have been reduced by Major Baird.

Account of the Registrations, &c., at each Station.

216. At Aden, the observations have been nearly continuous; the only stoppage that occurred was for a day, and that was occasioned by the necessity for cleaning the instruments during inspection. The aneroid barometer again proved defective, and had to be sent back to Mr. Adie for repairs. The anemometer worked fairly well. The observatory was inspected by Major Rogers in November, when decided retardation of water-flow was detected in the tube feeding the float-cylinder; this was found to be caused by shell-fish, which had settled on the perforations in the rose of the pipe; the latter was accordingly removed, cleaned, and replaced.

217. At Kurrachee, a good many stoppages occurred, but being all of short duration, the curves were easily restored by interpolation. The breaks were due to more causes than one; sometimes the wire between the pencil recorder and the sheave, broke; on other occasions the clock required to be corrected daily, or it stopped altogether: the inducing defects were remedied on inspection. The rose of the pipe feeding the float-cylinder required cleaning no less than three times, having been choked by shell-fish. The float-band unexpectedly broke in January, but the clerk in charge contrived to substitute a new one and to fix the zero very correctly. The aneroid barometer worked satisfactorily.

218. At Bombay, all the registrations were satisfactory and almost without any break; the exceptions being one of a day and another of two days, when the gauge-clock was under repair. All the instruments were cleaned during the inspection in December by Major Rogers. This observatory was also visited in October last by Mr. Hennessey, Officiating Deputy Surveyor-General, in charge Trigonometrical Branch.

219. At Kárwár, the series of observations was closed on 15th April 1883, all the registrations having been effected satisfactorily. The observatory was then dismantled for transportation to Goa, and advantage was taken of the interval thus occurring to send the whole of the instruments to England, where they are being thoroughly repaired, and also modified to meet present requirements, by Messrs. Légé and Co. But before removing the instruments, the zero of the gauge was verified and the level of the bed-plate tested by reference to the bench marks, and it was very satisfactory to find that this level had not altered in the whole course of observation, from 1st March 1878 to 15th April 1883. The observatory was inspected in December 1882 by Major Rogers.

220. At Beypore, all the observations have been most satisfactory, and with the exception of one short break of six hours, when the gauge-clock was cleaned, the registrations have been continuous. In December, retardation of water, ebb and flow, was noticed in the float-cylinder, which, as well as its feeding-pipe, were flushed out; after this the registration on the gauge-barrel and the independent reading of the actual sea-level on the graduated staff, agreed. There was a slight discrepancy in the working zero of the gauge, for which the diagrams were duly corrected. The observatory was inspected in January by Major Rogers.

221. At Pámban, on 28th December, the Port Officer reported that the high seas prevailing had not only washed the sand away from around the piles supporting the observatory, but rolling under and breaking heavily against the flooring, they lifted up the latter and deluged the instruments; he accordingly stopped the work and removed the instruments to a place of safety. It thus became impossible to avoid a *long* break of registration, and as the observations were in their fifth year, having been commenced on 1st October 1878, it was decided to dismantle the observatory; which was done also in view to transporting it to Ceylon, for one of the two localities, Colombo or Galle, where the Government has sanctioned the establishing of tidal stations. The instruments were all sent to England, where they will receive the repairs necessary after their long continuous services for nearly five years, and will also be suitably modified by modern improvements, by Messrs. Légé and Co.

222. At Negapatam, the registrations were most satisfactory as well as continuous, excepting a break from 26th to 31st December, when the instruments were removed by the Port Officer to a place of safety under apprehension that the prevailing boisterous weather would eventuate in a cyclone. Work being resumed, as indicated, Major Rogers took the precaution of sending Dhondu Venayek, sub-surveyor, to inspect the instruments, especially with regard to the gauge zero; he found that the instruments were working correctly; and further, he availed himself of the opportunity to clean and otherwise put them in good order. As regards the anemometer, its velocity gear ceased to work, and so it was put aside on 11th December by the Port Officer, until a new spindle was constructed. Major Rogers found all the instruments in good working order when he inspected the observatory in January.

223. At Madras, there were two sensible interruptions in tidal registration, one occurred from 18th February to 8th March, from choking of the cylinder feeding-pipe; this entailed taking up both cylinder and piping, and the gap mentioned in continuity of the work; the second break was due to necessary repairs to the gauge-clock, and lasted from 22nd to 27th July 1882: but with these exceptions, and one or two short and unimportant interruptions, the remainder of the observations has been continuous and satisfactory. The observatory was inspected by Major Rogers in February.

The tidal observations at the several ports in Madras are greatly facilitated by Captain J. H. Taylor, Master-Attendant, whose ready co-operation is of great value.

224. The waves caused by the stupendous terrestrial convulsion in the vicinity of Java were distinctly measured generally, on the tide-gauges around India, including the one at Madras, but as a separate report is made on this subject, it is not desirable to anticipate its facts here. This much, however, may be mentioned as to Madras, where the unusual behaviour of the register was reported to the Master-Attendant, who concluding that something had gone wrong in the apparatus, gave orders to stop and clean its constituents; so little evidence, apart from the silent registration of the gauge, was there to anticipate the tidings from Java, which of course followed subsequently. He, however, fortunately thought better to reverse his decision and to let the gauge continue making its abnormal markings, and thus the valuable wave record during the disturbance, was secured.

225. At Vizagapatam, the observations were suspended from 7th November 1882 to 14th January 1883; this was unavoidable to admit of strengthening or renewing the piles on which the observatory stands. The Port Officer replaced the instruments very carefully; but owing to alterations in the building, it was found, on Major Rogers' inspection in February, that

the bed-plate was too low by 0·109 foot. There were one or two unimportant stoppages of the gauge-clock between 14th January and 13th February; subsequently the gauge has worked very satisfactorily. The whole of the instruments were of course cleaned when inspected: later on in June the aneroid clock gave trouble, and had to be repaired.

226. At False Point, it will be remembered a gradual but diminishing sinking of the observatory was detected by comparisons of height between the bed-plate and bench marks on stable ground; no such settlement occurred during the past year. The registrations may be considered fairly continuous, except between 2nd and 22nd October, when the gauge-clock was at Calcutta for repairs, and, apart from short periods of unimportance, when the clock stopped. On the whole the stoppages were more numerous here than at the other stations. The aneroid barometer clock stopped and was detained for three months at Calcutta, under repairs. Similarly the mercurial barometer was absent for some five months. The anemometer worked most satisfactorily. Major Rogers inspected the observatory in February.

227. At Kidderpore, there were some half a dozen stoppages of the gauge-clock, each of about 12 hours duration; but as in these intervals the hourly readings were marked by hand on the diagram, the curves were readily interpolated subsequently. The aneroid barometer and the anemometer have worked well throughout the year. As regards the maintenance of the gauge zero, attention is called to Major Baird's remarks in the appendix, where the co-efficients evaluated are discussed. The observatory was inspected by Major Rogers in March.

228. At Diamond Harbour, the gauge-clock alone gave trouble: it stopped repeatedly, until at last there was substituted for it, one of the chronometer escapement clocks which have been specially provided for staging such as at this station, unsuited to pendulums. This substitute had performed well at Kidderpore; here, however, a piece of the hair spring unexpectedly snapped off, and the diminished spiral then remaining causing so large a gaining daily rate as 40 minutes, the old pendulum clock was necessarily restored: the latter has behaved sufficiently well since.

Remembering that Kidderpore and Diamond Harbour tidal stations are riverain stations, and that the river soundings at the latter are referred to the level of the Kidderpore dock sill, it is very desirable that our tide-gauge zero at Diamond Harbour should correspond with the last mentioned datum or level; this has been made feasible by the line of spirit-levels which now connects the two tidal stations, besides numerous other points: the required setting of the zero gauge has accordingly been made. For further remarks on this head, attention is called to Major Baird's discussion of the co-efficient for Diamond Harbour, in the appendix.

229. At Dublat, the clocks of both the gauge and the aneroid barometer stopped frequently, but only for short periods, so that the absent portions of the curves were readily interpolated: the circumstances attending the stoppages indicate the unsuitability of pendulum clocks for this station. Apart from the unimportant breaks mentioned, the registrations were fairly satisfactory. The observatory was inspected in April by Mr. G. Belcham, Surveyor, 3rd grade.

230. At Rangoon, the tide registration has been interrupted on four occasions, but only for short periods, which admitted of interpolating the curves easily. The aneroid barometer clock stopped frequently, and must be exchanged for one of the new ones expected shortly.

The anemometer worked fairly well. The zero of the tide-gauge has remained constant. The observatory was inspected by Major Rogers in April.

231. At Elephant Point, the observations have unavoidably been in abeyance. It will be remembered that as the site on which the observatory stood was nearly washed away by the river, Major Rogers and Mr. Ring selected a new site, to which the Port Engineer was directed to remove the structure: not only, however, were the materials for the building lost while in course of being transported on a raft, but the observatory substituted was set up by the last mentioned officer on a site of his own selection, which was both being cut away and was so low that the tide rose two feet above the

floor of the structure. On this, the Port Commissioners ordered its removal to the site chosen by Major Rogers and Mr. King, where the observatory now stands in safety, and the observations will be resumed as soon as possible.

232. At Moulmein, the stoppages of the gauge-clock though very frequent, were of short duration, so that the absent portions of the curves were easily restored; the stoppages were due to vibrations of the wharf, caused by freshets or impact, of bamboo rafts, &c. Breaks also occurred in registrations of the aneroid barometer and the anemometer; but on the whole the records of observation have been fairly continuous. The observatory was inspected in March by Major Rogers.

233. At Amherst, a prolonged break of 24 days occurred in the tide registration, on account of necessary repairs to the pipe connecting the cylinder with the sea: other short and unimportant breaks also occurred from stoppage of the clock, or from necessity for flushing out the cylinder, in which the mud held by the water is gradually deposited: this flushing out used to cause a break of so much as 24 hours, but Major Rogers made arrangements by which the work is now done in half that time. Excepting for the period of 24 days mentioned, all the other absent curves were easily restored by interpolation. The zero of the gauge required a good deal of attention from accidental breakages of gearing. The other instruments worked well.

On two occasions the window of the observatory was broken open and the gearing of the gauge displaced by some mischievous person: the offences were reported to the Deputy Commissioner in view to obtaining protection from the police. The observatory was inspected by Major Rogers in April.

234. At Port Blair, the observations were continued most satisfactorily, and without any breaks whatever; a marked success, greatly due to the supervision and cordial co-operation of Mr. Homfray, Port Officer, who took considerable interest in the work, and was always ready to afford any assistance required, so that the operations sustained a sad loss in his death, which occurred on the 24th February 1883: his successor, Mr. Brooks, continues the necessary supervision satisfactorily. The observatory was inspected by Major Rogers in March.

235. The preceding account shews that the registrations by the three self-recording instruments, tide-gauge, aneroid barometer, and anemometer, have been carefully and diligently supervised, and with great success; no doubt the weak points in all such automatic implements are the clock and other parts connected with the diurnal rotation of the register-barrel; and in the case of the clock a suitable balance-wheel is preferable to a pendulum, especially where there is liability to oscillation of the supports: this and other improvements are in course of adoption.

236. But besides the supervision of the registers, there is a considerable amount and variety of intricate operations, fully described in previous reports, which are also conducted by Major Baird in his fixed office, and which, besides meeting important requirements of science, also provide for the prediction of tides by means of the well-known India office machine. In all 18 groups of observations have been reduced, and the so called "constants" supplied to Mr. E. Roberts for computation of prediction tables by the tide-predicting-machine.

237. The tables for 1883 contain predictions for 18 Indian ports; those for 1884 will comprise, in addition, the Ports of Negapatam and Kathiwadar or Shial Bet. This particular and immediately practical outcome of the operations, will no doubt be of value for maritime purposes according to the accuracy of the predictions, which it will be remembered foretell the times and heights (above established data) of high and low water: to shew the accuracy at present attained, events as they actually occurred in the first-half of 1883 are contrasted with their predictions in the following tables for 15 ports, where it should be noted, that in several instances the outcome is obtained from inadequate data, being in some cases based on only *a single* year's observations.

No. 1.

Statement shewing the Percentage and the amount of the Errors in the predicted Times of High-Water at the various Tidal Stations for the first-half of the year 1883.

Station.	Number of comparisons between the actual and predicted values.	Errors of 5 minutes and under.	Errors over 5 minutes and under 15 minutes.	Errors over 15 minutes and under 20 minutes.	Errors over 20 minutes and under 30 minutes.	Errors over 30 minutes.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1. Aden	346	32	44	10	9	5
2. Kurrachee	350	30	36	13	13	8
3. Bombay	350	49	41	5	4	1
4. Kárwár	204	27	34	2	16	21
5. Beypore	350	14	30	10	20	26
6. Madras	350	19	30	11	25	15
7. Vizagapatam	324	36	46	12	5	1
8. False Point	350	37	43	7	8	5
9. Amherst	346	26	34	14	19	7
10. Port Blair	350	31	44	12	12	1
11. Dublat	350	31	36	14	13	6
12. Diamond Harbour ...	350	23	44	13	13	7
13. Kidderpore	350	28	43	14	10	5
14. Rangoon	349	30	45	11	11	3
15. Moulmein	344	34	40	13	11	2

No. 2.

Errors in the predicted Times of Low-Water.

1. Aden	346	31	40	10	14	5
2. Kurrachee	350	27	45	11	11	6
3. Bombay	350	32	45	10	10	3
4. Kárwár	204	20	36	15	15	14
5. Beypore	350	9	18	8	20	45
6. Madras	350	21	35	15	17	12
7. Vizagapatam	324	37	45	8	8	2
8. False Point	350	33	40	10	13	4
9. Amherst	346	21	37	16	17	9
10. Port Blair	349	34	47	7	9	3
11. Dublat	350	21	37	16	19	7
12. Diamond Harbour ...	350	17	36	16	20	11
13. Kidderpore	350	21	38	16	17	8
14. Rangoon	349	27	38	16	15	4
15. Moulmein	345	24	41	15	13	7

No. 3.

Statement shewing the Percentage and the amount of the Errors in the predicted Heights of High-Water at the various Tidal Stations for the first-half of the year 1883.

Station.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
1. Aden	346	91	8	1	.....
2. Kurrachee	350	76	21	3	.....
3. Bombay	350	69	26	4	1
4. Kárwár	204	84	16	.....	.....
5. Beypore	350	88	11	1	.....
6. Madras	350	75	23	2	.....
7. Vizagapatam	324	80	18	2	.....
8. False Point	350	85	13	2	.....
9. Amherst	346	32	24	20	24
10. Port Blair	350	98	2	.....	.....
11. Dublat	350	16	23	23	38
12. Diamond Harbour	350	44	31	20	5
13. Kidderpore	350	32	26	23	19
14. Rangoon	349	52	30	15	3
15. Moulmein	344	44	26	22	8

No. 4.

Errors in the predicted Heights of Low-Water.

Station.	Number of comparisons between the actual and predicted values.	Errors of 4 inches and under.	Errors over 4 inches and under 8 inches.	Errors over 8 inches and under 12 inches.	Errors over 12 inches.
		Per cent.	Per cent.	Per cent.	Per cent.
1. Aden	346	95	5	.....	.....
2. Kurrachee	348	80	17	3	.....
3. Bombay	348	76	21	3	.....
4. Kárwár	204	64	32	4	.....
5. Beypore	349	63	33	4	.....
6. Madras	350	80	19	1	.....
7. Vizagapatam	325	85	15	.....	.....
8. Palse Point	350	77	21	2	.....
9. Amherst	332	24	23	20	33
10. Port Blair	349	99	1	.....	.....
11. Dublat	349	23	28	24	25
12. Diamond Harbour	349	53	29	13	5
13. Kidderpore	350	34	30	21	15
14. Rangoon	350	45	27	15	13
15. Moulmein	345	53	26	15	6

238. Of these ports, the oceanic are 1 to 8 around the Indian Peninsula and 9 and 10 in Burma and the Andamans; the riverain are 11 to 13 on the Hooghly and 14 and 15 in Burma. Between the oceanic and riverain predictions, there is this great difference, that the latter are liable to be vitiated by local causes, which, in absence of more complete methods, Mr. Roberts has endeavoured to overcome provisionally by modifications explained in a previous report (1881-82); stated briefly, the following are the average high and low water *percentage* of error predictions obtained from tables Nos. 1 to 4 for the 4 groups of stations above mentioned:—

Stations.	Time, Minutes.			Height, Inches.		
	0 to 15	15 to 30.	Over 30.	4 to 8.	8 to 12.	Over 12.
Oceanic 1 to 8, India	67	23	10	98	2	0
„ 9 and 10, Burma and Andamans	69	26	5	76	10	14
Riverain 11 to 13, Hooghly ...	63	30	7	62	21	17
„ 14 and 15, Burma ...	70	27	3	76	17	7

which reads thus: for the oceanic group 1 to 8, India, of 100 predictions, 67 were in error under 15 minutes in time, 23 were in error from 15 to 30 minutes, and 10 over 30 minutes: and as to height, 98 were in error under 8 inches and two in error from 8 to 12 inches, and similarly for the other groups. The riverain predictions, so far as the limited observations at present go, appear quite as good as the oceanic *in respect to time*, but not so *in respect to height*: in fact local disturbances are less likely to affect the argument of time than that of height.

239. Major Baird rightly dwells (*see* appendix) on the valuable modifications suggested by Professor G. H. Darwin in consultation with Professor J. C. Adams to be adopted in the final analysis of both the short and long period tides; indeed, the Indian tidal operations are greatly indebted to the kindness and well-known abilities of these gentlemen.*

240. Some time back it was apprehended that a misprint which had crept into the tidal report of the British Association, 1872, may have vitiated the reductions of the Indian long-period tides; but on Major Baird's return to India, he ascertained that the error fortunately had not been adopted in his calculations.†

* See "Report of a Committee (British Association for the Advancement of Science—Southport, 1883), consisting of Professors G. H. Darwin, and J. C. Adams, for the Harmonic Analysis of Tidal Observations: drawn up by G. H. Darwin." Complete copies of this report reached me *after* the foregoing summary of tidal operations had been sent to press; yet not too late, I trust, to admit of my hearty, though necessarily brief, acknowledgments for the invaluable exposition and directions it contains; by which the results of the Indian Tidal Observations will be greatly improved, both for immediate use and for purposes of future discussion, and will represent, in gains practical and scientific, the valuable time so generously bestowed on the investigations.

† Major Baird reports of Mr. Rendell, that he is "most useful" and of Mr. Connor, that "he devotes himself most thoroughly to his work."

XXVI.—THE TIDAL DISTURBANCE CAUSED BY THE VOLCANIC ERUPTIONS AT JAVA ON 27TH AND 28TH AUGUST 1883.

241. The existence of the numerous self-registering tide gauges established on the various ports on the coast of India in connection with the Survey of India has offered an unique opportunity of observing the tidal phenomena resulting from the great eruption of Krakatoa in Java. The series of self-registers is remarkably complete. and it is only to be regretted that the new tidal observatories now sanctioned to be erected at Colombo and Galle in Ceylon were not then in existence. Major A. W. Baird, R.E., the Deputy Superintendent in charge of the tidal operations, has submitted a full report on the whole subject, but at a date, viz., December 1883, which has precluded it being reviewed by the Deputy Surveyor-General, who is now superintending the Trigonometrical Branch, in such time as to admit of his remarks being published in this report. But this defect may be provided for by presenting the substance of a paper read before the Royal Society on the 31st January last by General J. T. Walker, C.B., R E., Surveyor-General of India, now on furlough, who explains the nature of the observations recorded and of the investigation resulting therefrom, and their bearing on the interesting subject of the progression of tidal waves. It will be remembered that this subject is one with which General Walker is peculiarly capable of dealing, the institution of the tidal operations having been originated under his direction, and fostered by his careful supervision.

"The principal facts set forth by Major Baird are the following:—

1st.—The primary effect of the great eruption at Krakatoa was a marked fall in the sea-level, or in other words, the formation of a negative supertidal wave at each of his stations.

2nd.—This negative wave was succeeded by a great positive wave at an interval ranging from seventy-five minutes at Negapatam, the station nearest Krakatoa, to twenty-four minutes at Aden, the most distant station.

3rd.—Supertidal wavelets of greater or less magnitude were registered at the whole of the Indian stations some hours, more or less, before the effects of the great eruption; they are evidences of antecedent minor eruptions, the occurrence of which they would establish even in the absence of all other information on the subject. The intervals between these warnings and the great eruption which they heralded range from about three hours at Aden, the most distant station, to eighteen hours at Negapatam, the nearest station. This shows that the explosions were at first comparatively faint and feeble, being felt only at the nearest stations, but afterwards they increased in intensity, becoming sensible even at the most distant station three hours before the effects of the great eruption.

4th.—Great supertidal waves of amplitudes, ranging from a maximum of 22 inches at Negapatam to a maximum of 9 inches at Aden, were registered at all the stations which were in a position to receive the full force of the eruptions at Krakatoa, unobstructed by the configuration of the foreshore. Other waves of less magnitude, ranging down to half the maxima values, occurred at these stations at intervals of one to two hours for about twelve hours after the first great wave.

5th.—The secondary great waves were succeeded by wavelets gradually diminishing in size, but continuing for some time. They are traceable on the diagrams for the 29th and 30th August, the second and third days after the great eruption. They cease first at Port Blair about 8 P.M. of the 29th, at Negapatam at 4 A.M. of the 30th, and lastly, at Aden at 5 P.M. of the 30th.

6th.—Loud reports resembling the firing of distant guns were heard at Port Blair and on the Nicobar Islands on the 26th and 27th August, and being supposed to be signals from a vessel in

distress, a steamer was sent out in search of the vessel. Similar reports were heard at two places on the coast of Ceylon on the 26th, first at 6 P.M., and afterwards at midnight.

These facts show clearly that the terrible eruption at Krakatoa, which carried desolation over the surrounding regions, and was attended with such an appalling loss of life, was preceded for some hours by minor eruptions which were insignificant only by comparison, for they produced effects which were sensible even at Aden, a distance of upwards of 4,000 miles. It is possible, therefore, that some at least of the subsequent supertidal waves may be due to eruptions occurring subsequently to the great eruption.

It is a singular fact that we are still without any precise and definite information of the time at which the great eruption took place. In a very interesting and suggestive note on the barometrical disturbances which passed over Europe between the 27th and 31st August, communicated to the Royal Society on the 12th December, General Strachey gives an investigation of the speed of barometric waves travelling from Krakatoa round the earth, some from east to west, others from west to east, and estimates that the great disturbance which caused the initial barometric rise probably occurred at 9h. 24m., local time, on the morning of the 27th August. Now Major Baird shows that the primary effect of the great eruption was to produce a recession or fall of the sea-level at each of his tidal stations, and this was also noticed at the Mauritius. It seems probable that the initial barometric rise occurred at the same time as the initial oceanic fall or the great negative wave, and that this again preceded the first great positive wave by an interval ranging from 75 minutes at the nearest Indian station to "about a quarter of an hour" at the Mauritius. Major Baird has ascertained from Her Majesty's Consul at Batavia that the first great positive wave reached Batavia at 12 h. 10 m., mean local time, on the afternoon of the 27th August. He infers from the table of the velocities of free tide waves in Sir George Airy's article on tides and waves in the *Encyclopedia Metropolitana*, that as the distance from Krakatoa to Batavia is about 105 miles, and the average depth of the sea between them 186 feet, the wave must have taken about two hours to travel the distance. Thus, allowing five minutes for difference of longitude, the local time of the occurrence of the first great positive wave at Krakatoa would be 10 h. 5 m. A.M., or about 1 h. 40 m. later than General Strachey's estimated time of the initial barometric rise. If, however, we assume this time to have been identical with that of the initial oceanic fall, and to have preceded the first great positive wave by an interval somewhat greater at Krakatoa than at the nearest India station—an inference to be drawn from the fact that all the recorded intervals between the negative and positive waves increase as the distances from the centre of disturbance diminish—the difference between General Strachey and Major Baird will practically disappear. When we consider the absolute independence of the two methods of deduction which they have respectively employed, the facts of the one being derived from the atmosphere, while those of the other are derived from the ocean, the coincidence between the two results appears very striking.

The Admiralty chart of the Eastern Archipelago shows that Krakatoa is situated at the focus of what may be regarded as a parabolic figure formed by the configuration of the contiguous portions of the coasts of Java and Sumatra. The axis of the figure is directed westwards towards the Indian Ocean, and nearly at the apex there is an opening to the north-east formed by the Straits of Sunda. Thus the waves generated by an eruption at Krakatoa would be mostly propelled towards the Indian Ocean, both directly, and though in a minor degree, by reflection from the coasts. The rush of waters towards the coasts would only have one outlet, namely, the Straits of Sunda, through which, as is well known, a great wave passed, carrying widespread destruction for some distance beyond along the contiguous coasts of Java and Sumatra. This wave may possibly have impinged with great force on the south-west coast of the Island of Borneo, which is on the prolongation of a straight line drawn from Krakatoa through the Straits of Sunda. But to the north-west, at Singapore, no trace of tidal disturbance appears to have been met with. A self-registering tide-gauge is established there, and the distance from Krakatoa is less than one-third of that of the nearest Indian station; but the Master Attendant

reports that the gauge records " no difference whatver in the tide." This may be due to the fact that the wave through the Straits of Sunda, when it bent round to the north-west towards Singapore, had but a shallow sea to advance over, and its course must have been greatly impeded by the numerous islands and shoals and the narrow straits and passages between them; thus it may have well broken up and disappeared at some distance short of Singapore.

In an appendix to his report, Major Baird gives the respective velocities with which the great primary positive wave travelled to Galle, the Mauritius, the cost of Africa, and three of his own stations. He necessarily assumes that the as-yet-unknown time at which this wave issued from Krakatoa is to be fixed from the known time of its advent at Batavia by deducting two hours from the latter in accordance with the velocity table in Airy's Tides and Waves already referred to. He obtains for the maximum velocity 467 statute miles per hour, both for Port Louis, in the Mauritius, distant 3,400 miles, and for Port Elizabeth, in South Africa, distant 5,450 miles. That the same value should be obtained for two places, one of which is 2,050 miles further from the origin than the other, shows that there is not likely to be any gross error in the time adopted for the starting of the wave from Krakatoa. The value is moreover interesting in that it is practically identical with Airy's velocity of a free tide wave passing over an ocean 15,000 feet, which is approximately the depth of the ocean on this line. In other directions the velocities are less, namely, towards Galle, 397; Negapatam, 355; and Aden 371 miles. In the calculations the velocity has been assumed uniform in each instance as a matter of convenience, but it must in reality have been greatest wherever the ocean depth was greatest. The greatest depth is known to occur on the lines to Ports Louis and Elizabeth for which we have the greatest velocities; but the wave which impinged on the Indian stations, and eventually reached Aden, must for a considerable portion of its course have been identical with the wave which impinged on Ports Louis and Elizabeth, and then it must have travelled with the same high velocity; afterwards, on passing over shallower oceans, its velocity must have been materially retarded, and may have fallen much below the averages, 355 to 397 miles, for the whole course. This appears probable, moreover, from the evidence of the earthquake in the Bay of Bengal on the 31st December 1881, of which an account, communicated by myself, was published in the " Proceedings of the Asiatic Society of Bengal" for March 1883. The position of the centre of impulse has been fairly well fixed at a point nearly on the line between Port Blair and Negapatam, and the time is known within a few minutes. The supertidal waves caused by this earthquake at the contiguous tidal stations much exceeded in magnitude, the waves caused at the same places by the eruption at Krakatoa, but their velocity was found to range between 240 and 120 miles an hour, varying with the general depth of the water traversed and the configuration of the foreshore at the respective stations. It is probable, therefore, that for the latter portion of its course the wave from Krakatoa to the same stations travelled with no greater velocity than on the occasion of the earthquake in the Bay of Bengal."

XXVII.—THE SPIRIT-LEVELING OPERATIONS.

1.—THE OPERATIONS EXECUTED IN CONNECTION WITH THE TIDAL OBSERVATIONS.

242. These operations were carried out for four different purposes, which however mostly admitted of being promoted simultaneously. The purposes in view were as follows:—

I.—To connect the bench marks between Chinsurah and Kidderpore, laid down in 1862-63 by the (old) line of levels brought from sea-level at Kurrachee, with the tidal station at False Point.

II.—To connnect the tidal stations of Kidderpore, Diamond Harbour, Dublat, and False Point with one another.

Personnel.

Major M. W. Rogers, R.E., Officiating Deputy Superintendent, 3rd grade, in charge up to 16th April 1883

Major A. W. Baird, R.E., Officiating Deputy Superintendent, 3rd grade, in charge from 19th April 1883.

Mr. G. Belcham, Surveyor, 3rd grade.

„ A. Christie „ 4th „

Sub-Surveyor Narsing Dass, and three Recorders.

III.—To lay down along both banks of the Hooghly, permanent bench marks for the Hooghly River Survey, and to connect, for the purposes of the Calcutta Port authorities, the so-called "marine sockets" already placed at intervals of about a mile.

IV.—To connect the nearest principal stations of the Great Trigonometrical Survey, to lay down bench marks in Calcutta for general use, and otherwise to run short branch lines wherever necessary.

243. In pursuance of these objects, a line was run in 1881-82 from False Point tidal station, *viâ* Jajpore, Balasore, Jellasore, Contai, &c., to Kukrahati, and across the Hooghly *viâ* Diamond Harbour to Saugor Light-house and Dublat tidal station.

244. During the present season, certain branch lines of the previous operations were completed, and the work continued and finished by means of the following lines:—

From the bench mark near the tidal observatory at Diamond Harbour, along the main road to Kidderpore tidal station in the Dockyard, and thence *viâ* the bench mark at Prinsep's Ghat (Kurrachee line) across the river to Howrah, where, after connecting with all available stations of the old (Kurrachee) line, the levels terminated at the bench mark cut on the steps of the East India Railway station, having also fixed two bench marks on the premises of the Mint, besides several others on basements of statues, fountains, and other permanent structures along the Strand.

From Howrah Railway bench mark, along the road on the right bank of the Hooghly, *viâ* Goosery, Uttarpara, Serampore, to Chinsurah bench mark, making several important connections with bench marks of the old (Kurrachee) line, besides many other fixings.

From Kidderpore bench mark along the embankment on the left bank of the Hooghly *viâ* Akra, Atcheepore, Phalta, to the bench mark near Hooghly point, fixing permanent bench marks, marine sockets, &c., &c.

From Howrah Railway bench mark along the right bank of the Hooghly, *viâ* Saringa, Fort Gloster, Oolaberiah, across the Damoodur and Roopnarayan rivers to Kukrahati* and onwards along the embankment and across the Haldi river *viâ* Kedgeree, Kankhali Light-house, to the bench mark at the mouth of the Rasulpur river, fixing permanent bench marks, marine sockets, &c.

245. These operations were entrusted to Mr. Belcham, who was assisted by Narsing Dass, sub-surveyor, in the capacity of second or check observer. The out-turn for the season is shown in the following table:—

Statement showing Out-turn of Leveling, season 1882-83.

Name of Line.	Main line; distance.	Branch line; distance.	Number and Description of Points connected.								
			Embedded B. Ms.	Inscribed B. Ms.	Marine sockets.	Marine survey B. Ms.	Railway B. Ms.	Public Works Department and Irrigation B. Ms.	Trigonometrical stations.	Kurrachee Line B. Ms.	River Survey stations.
	Miles.	Miles.									
Diamond Harbour to Howrah ...	33·1	0·8	8	27	.....	.....	.....	44	1	3	.....
Kidderpore to Diamond Harbour ...	40·8	1·9	5	14	28	6	.....	22	.....	.....	5
Diamond Harbour to Barotolia River	.....	11·4	4	1	8	.....	.....	.....	.....	.....	.....
Kukrahati to Rasulpur River ...	61·0	10·4	9	42	20	2	.....	1	2	.....	1
Ditto to Howrah	43·6	4·7	10	12	22	1	1	2	1	1	8
Howrah to Chinsurah	33·1	0·2	6	12	.....	.....	1	.....	1	8	.....
Total ...	206·6	29·5	42	108	70	7	2	69	5	12	14

Briefly stated, the lines were leveled over a total of 236 miles in length, and fix 329 bench marks; results which are very creditable to Mr. Belcham's zeal, activity, and good arrangements. Nor were unusual difficulties absent, more particularly along the right bank of the Hooghly river, where in absence of a regular embankment for roadway, and of bridges over the numerous

* This section was actually leveled in the reverse direction i.e. from Kukrahati to Howrah.

creeks, the surveyors were harassed and exposed to an extent which for a time induced bad health, panic, and desertions. Noting some of his troubles, Mr. Belcham writes:—

"Between the Roopnarayan and Howrah, during each day's leveling, more than a dozen creeks had to be crossed; at high tide they were easily got over, as I had a boat in attendance, but at low tide we had to wade through them, which was not only uncomfortable, but was attended with great risk to the instruments, as the men often sank up to their waists in the mud and slush.

The baggage had to be conveyed by boat while working along the river bank, which often occasioned delay, as wind and tide had to be consulted. Loading and unloading the boats was at times very awkward and laborious, owing to their having to remain far out from land"*

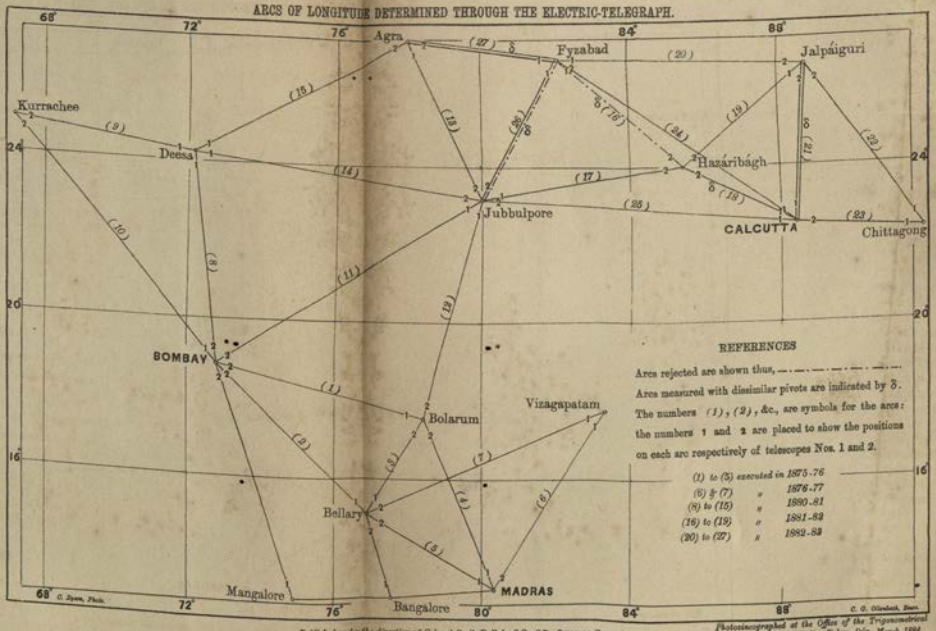
246. The line of spirit-levels between the sea-levels at Kurrachee on the Indian Ocean and at False Point on the Bay of Bengal, of which the last connecting link has now been completed, is deserving of at least brief notice. It runs from Kurrachee, broadly speaking, up the Indus to Mithankot and onwards *viâ* Ferozepore, Agra, Allahabad, Monghyr, and Calcutta, to False Point, a distance of some 2,300 miles. If this distance be converted into longitudinal degrees for the latitude of London, it represents, say, 53° of longitude, and if stretched out about eastwards would reach from London straight across the Channel, Germany, and all Russia to Astrakan. This will give a practical and familiar illustration of the great length embraced. It is most probably the longest line ever run between two seas, and the error in leveling, so far as is known, does not exceed 1·7 feet, or under three quarters of a foot per thousand miles: in its absence, accurate sea-level as a datum was unknown throughout the vast length it traverses.

247. In addition to the foregoing, subsidiary single lines of levels were run by a detachment from the Tidal and Leveling party in the districts of Khandesh and Ahmednagar mostly, in order to correct the old trigonometrical heights in those localities executed some 40 years ago, when the modern method of dealing with terrestrial refraction was not known: in all, 180 miles were leveled over, and the heights of 138 bench marks, Trigonometrical, Railway, and Irrigation Department, were determined. The revision of the trigonometrical heights was continued by Mr. Christie on the Khanpisura Series, who completed a satisfactory season's work with care and judgment.

2.—THE OPERATIONS IN CONNECTION WITH THE REVENUE SURVEY.

248. The small party of levelers attached to the Hanthawaddy District Survey Party resumed its operations at Henzada, the closing point of the previous season, to continue the scheme of levels for the Irrawaddy valley. The first section measured, was carried from Henzada, where it crossed the Irrawaddy, to Thonzeh on the railway line, which completed a circuit through the railway levels and Hanthawaddy District Series, back to the starting point of last year at Twantay. As the railway levels were said to have been carefully taken along this part of the line, and were also found to accord very fairly over a short section of 20 miles which had been re-leveled the previous season, a uniform correction was applied throughout the circuit. The closing error is 0·0369 foot per mile. The next section measured was from Henzada to Prome, where a connection was again made with the railway, and another circuit completed through the railway levels back by Thonzeh to Henzada. In this, though a very small circuit compared with the previous one, the closing error was much greater. The railway levels in this part were admitted to be doubtful, and it was decided, after re-measurement of short lines over-lapping the junctions to check the work at those points, to adopt the same correction for the new work as had been required for the previous section, and to close the circuit by throwing a somewhat heavier correction per mile into the railway levels. The total length of the leveled sections is 188 miles, with double leveling throughout. Bench marks have been established on 24 existing objects and on 206 specially placed marks.

* Major Baird writes:—"Of Mr. Belcham I cannot speak too highly * * * In every way he performs his duties to my entire satisfaction."



Published under the direction of Colonel G. C. DuFrés, R.C., Offg. Surveyor General of India.

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, March 1884.

GEODETIC.

XXVIII.—ELECTRO-TELEGRAPHIC LONGITUDE OPERATIONS.

249. The measurements of arcs of longitude through the electric telegraph were continued, as before, by the Astronomical Parties Nos. 1 and 2. The former party was conducted into the field by Colonel Campbell, who also continued the observations, and otherwise co-operated in the work, until the return of Major Heaviside from furlough. No. 2 Party was throughout the season under charge of Major Strahan, excepting a period of $3\frac{1}{4}$ months, when, the latter officer being ordered to do duty in the office of the Survey of India, Calcutta, the former was placed in charge of both parties, and the calculations were conducted by him. He was also aided by two computers from the Computing Office.

Personnel.

(No. 1 Astronomical Party.)

Lieutenant-Colonel W. M. Campbell, R.E. (in charge to 5th December 1882), Deputy Superintendent, 2nd grade.
Major W. J. Heaviside, R.E. (in charge from 6th December 1882), Deputy Superintendent, 3rd grade.
Mr. D. Atkinson (from 3rd August 1883), Surveyor, 1st grade.
Sub-Surveyor Dhondo Balwant Joshi.

(No. 2 Astronomical Party.)

Major G. Strahan,* R.E., Deputy Superintendent, 2nd grade.
Mr H. E. T. Keelan, Surveyor, 2nd grade.
Sub-Surveyor Babu Harsahai.

* Temporarily employed at Calcutta as Assistant Surveyor-General, and therefore absent from party from 23rd April to 31st July 1883.

In all, eight arcs were measured, *i.e.*,—

‡ Jalpaiguri-Fyzabad.
† Jalpaiguri-Calcutta.
* Chittagong-Jalpaiguri.
* Chittagong-Calcutta.
‡ Calcutta-Fyzabad.
‡ Calcutta-Jubbulpore.
† Fyzabad-Jubbulpore.
† Fyzabad-Agra.

Of these, the three arcs† were re-measurements, rendered necessary by unexpected failure in the attachments of No. 2 telescope as explained in the report for 1881-82; the three arcs‡ were introduced to strengthen and verify the old work, and the two arcs* were new ones. Throughout the season the previous disposition of the instruments was maintained; *i.e.*, Major Strahan used No. 2 telescope, and Major Heaviside telescope No. 1. Both instruments were carefully examined during the recess in the Mathematical Instrument Office, Calcutta, and the attachments of the two ends of the telescopes to the cube of the transit axis were strengthened considerably: these improvements were first inspected at Calcutta by Colonel Campbell and Major Strahan: the field-work was then taken up, in such a manner as to limit the revision to a minimum: in fact, it has been found necessary to reject only two arcs of the old measurements, as will be seen further on.

250. It will be remembered that the particular error developed in the observations of 1881-82 was (*triangular*) circuit error. The arcs here first discussed are in view of this error, and extend from (13) to (21) of the diagram facing this page, where the arcs are numbered in the order they were measured. The following Table T gives briefly the observed values of the arcs and the corrections deduced under certain conditions A and B.

TABLE T.

Observed Arcs and Corrections from (Triangular) Circuit Equations.

Observed Values of Arcs.				Symbolical arcs.	Corrections under conditions.		Corrected arcs under conditions.
Hours and minutes.	Seconds.				A.	B.	B.
	1880-81.	1881-82.	1882-83.				
1	2	3	4	5	6	7	8
H. M.			s.				H. M. s.
0 26	.....	.....	22·992	(20)	−0·029	+0·018	0 26 23·010
1	.....	30·462	30·286	(21)	− ·010	− ·010	1 30·334
24	.....	.....	52·665	(24)	− ·036	+ ·011	24 52·676
33	.....	.....	37·658	(25)	− ·026	− ·026	33 37·632
8	.....	*44·629	44·926	(26)	+ ·077	+ ·030	8 44·956
12	.....	†55·714	.....	(16)	+ ·140	‡+ ·234	12 55·948
13	.....	27·071	.....	(19)	+ ·038	− ·009	13 27·062
11	.....	56·724	.....	(18)	+ ·051	+ ·004	11 56·728
21	.....	40·908	.....	(17)	− ·051	− ·004	21 40·904
16	...	27·932	27·993	(27)	.....	.....	.....
7	42·993	.....	.....	(13)	.....	.....	.....

* Rejected in both conditions A and B.
† Rejected in B.
‡ Deduced.

251. Here the double values of (27), (26), and (21) invite criticism at the outset: it will be seen in Table T that the two values of (27) differ by only $0^s{\cdot}061$, and those of (21) differ by $0^s{\cdot}116$. In these two cases the means are adopted: with respect to (26) however, one of the two values must be rejected; that for 1881-82 or (26) is obviously at fault, for the circuit error of 1881-82 or (27)—(13)—(26) = $0^s{\cdot}310$, and compared with the value of 1882-83 or (26_2) we have (26_2)—(26_1)=$0^s{\cdot}297$., besides other evidence on which (26_1) is rejected. With the values of Table T which now remain, *including* (16) (to be rejected presently), the corrections deducible as usual by the method of minimum squares* are those given in column A of Table T. It is however shown in the margin, that in the three equations, *including* (16) the average circuit error is so much as $\frac{1}{4}$ second nearly, and in the 4 other equations where (16) is absent the average error is only some $0^s{\cdot}03$: on this evidence (16) is rejected, after which the resulting corrections are those in column B: further, if from the corrected arcs in the last column we *deduce* a value of (16) and contrast it with the observed value, the error of the latter as may be expected is large, *i.e.*—$0^s{\cdot}234$. In fact, there can be no doubt, that, in view of the evidence, the conditions B give by far the more truthful results. As regards the sums of the squares of the corrections, excluding that to (16), we have—

Circuit errors.

In which (16) is present...	−0·268 −0·207 −0·227
In which (16) is absent ...	+0·017 −0·067 −0·003 −0·026

Sums of squares by	A	...	... 0·016
Ditto	B	...	... ·002

So far the measurements of 1882-83, combined with those of the preceding year, lead to satisfactory results after the two erroneous measures are detected and rejected. But the measurements of last season show a continuance of the peculiar facial difference, first decidedly developed in 1881-82, which requires discussion.

Briefly stated, the result sought is difference of longitude or Δ L; this may be measured under three conditions as to the directions of the illuminated pivots (I. P.); *i.e.* (*a*) similar pivots, or when the I. P. in *both* instruments points east (E) or west (W); (*b*) or when one I. P. points E, and the other W; and (*c*) a combination of (*a*) and (*b*). The condition (*c*) was adopted only on 4 arcs, and that in 1881-82, when the telescopes were not reliable: hence in the discussion following, the condition (*a*) of *similar* pivots is alone considered, and this in effect excludes all the measurements of 1881-82.

252. Now, without entering into needless details, let

$_{E}\Delta$ L be the mean result of several other results, each the mean of many observations, *all* with I. P. E.,

and

$_{W}\Delta$ L be d°. d°. d°. d°. I. P. W.

where the components of each mean result, considered by themselves, are accordant; yet it is found that $_{E}\Delta$ L — $_{W}\Delta$ L is a sensible quantity, and this of course *after* application of the usual instrumental and personal corrections; so that the discrepancy is a *residual*, and means, that the telescopes instead of moving along their meridians, trace courses east or west of them. Now, the telescopes being distinguished by Nos. 1 and 2, suppose x_1 and x_2 (reckoned + when traced west of the meridians) respectively to denote their residuals for I. P. E., and that — y_1 and — y_2 are the corresponding residuals for I. P. W. Then, if No. 1 be at the west station (Wt),

Error of $_{E}\Delta$ L = (x_1 — x_2) = say X for I. P. E. & No. 1 Wt.	...	Q·3
Do. $_{W}\Delta$ L = — (y_1 — y_2) = say — Y for I. P. W. & No. 1 Wt.	...	Q·4
$\therefore$ $_{E}\Delta$ L — $_{W}\Delta$ L = X + Y for No. 1 Wt.	...	Q·5†

here it is of considerable importance to notice that X and Y will change sign if the two instruments are supposed to be transposed between the two stations, and this *without* change of pivot. For instance, if the arc be A and No. 1 be

* The weights used are all taken at unity: these are as good as any other empirical weights if not better, and rigorous weights are practically not attainable, (1) because of entanglement, (2) and presence of errors which probabilities do not recognise.

† This is commonly known in the Survey Department as the E-W equation, but those two letters having already been made to do symbolical duty for several purposes, it is preferable to use X and Y as above.

Wt and No. 2, Et, this may be conveniently indicated by ${}_1A_2$; its error for I.P.E. by Q. 3 will be X: but if the instruments be transposed in imagination, the arc would be suitably indicated by ${}_2A_1$, and its error without changing pivots would be $-X$: similarly of Y.

253. Now the usual way of determining $(X+Y)$ as *one* quantity, is that indicated by Q. 5, but though it is not possible to find each of x and y from the present series of measurements on *similar* pivots, each of X and Y may be determined separately, thus. In any circuit of three arcs* (or triangular circuit), there is the equation ${}_1A_2 - {}_2B_1 - {}_1C_2 =$ say α ..... Q. 6 where α is a *numerical* quantity found from measures *entirely* I. P. E.; but by Q. 3, each arc contains X, hence substituting in left member of equation there results—

$$X = -\alpha \quad \ldots \quad \ldots \quad \ldots \quad \text{Q.7}$$

but if instead of Q. 6 the equations were, for example—

$${}_1A_2 - {}_2B_1 - {}_1C_2 = \text{say } \alpha \quad \ldots \quad \ldots \quad \text{Q.8}$$

Then we should find $X = \alpha$ Q.9

And similarly proceeding with measures *entirely* I. P. W., there will result—

$$Y = \text{say } \beta \quad \ldots \quad \ldots \quad \ldots \quad \text{Q.10}$$

hence from Q.9 and Q.10 we obtain $X+Y$ to contrast with Q.5; and also $\frac{1}{2}(X-Y)$ which is *the* circuit error, if in Q.6 we use the *mean* values from I. P. E. and I. P. W.†

254. Proceeding in the manner indicated, the following Table B is formed, in which the residuals X and Y are exhibited necessarily for *one and the same* imaginary instrumental disposition: the disposition assumed is No. 1 Wt and No. 2 Et.‡

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* If the number of arcs in a circuit be even, cases may arise when the co-efficient of X in Q.6 or of Y in the corresponding equation, may be 0; when α (or β) would be the outcome of *ordinary errors of observation*.

† The residuals X and Y are inseparable from the ordinary errors of observation, which may or may not exceed them.

‡ Without this necessary precaution we should obviously be contrasting quantities not comparable, *i.e.*, equivalents of $+X$ (or $+Y$) with $-X$ (or $-Y$) at random.

TABLE V.

Year of observations.	Circuit number.	Illuminated pivot.	Circuit Arcs. Symbolical. +	−	−	Numerical. +	−	−	Arc result mean $(X+Y)$ from 7, 8, and 9	Circuit Results. X from I. P. E. from 7, 8, and 9.	Y from I. P. W. from 7, 8, and 9.	$X+Y$ from 11 and 12.	$\frac{1}{2}(X-Y)$ from 11 and 12.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
						m. s.	m. s.	m. s.	s.	s.	s.	s.	s.
		E				22 48·97	16 26·03	6 21·95	.....	+ 0·01	.....	.....	.....
1875-76 ...	1	W	$({}_2 1_1)$	$({}_2 2_1)$	$({}_1 3_2)$	48·83	26·98	21·82	.....	.....	+ 0·03	.....	.....
						X + Y − 0·04	+ 0·05	+ 0·13	+ 0·05	.....	.....	+ 0·04	− 0·01
		E				28 31·75	22 48·87	5 42·92	.....	− 0·04	.....	.....	.....
,, ...	2	W	$({}_2 11_1)$	$({}_2 1_1)$	$({}_2 12_1)$	31·81	48·83	42·92	.....	.....	− 0·06	.....	.....
						X + Y + 0·06	− 0·04	0·00	+ 0·01	.....	.....	− 0·10	+ 0·01
		E				13 16·46	6 21·95	6 54·66	.....	+ 0·15	.....	.....	.....
,, ...	3	W	$({}_2 5_1)$	$({}_1 3_2)$	$({}_2 4_1)$	16·63	21·82	54·73	.....	.....	+ 0·08	.....	.....
						X + Y + 0·17	+ 0·13	+ 0·07	+ 0·12	.....	.....	+ 0·23	+ 0·03
		E				25 26·37	13 16·46	12 9·71	.....	+ 0·20	.....	.....	.....
1876-77 ...	4	W	$({}_2 7_1)$	$({}_2 5_1)$	$({}_2 6_1)$	26·41	16·63	9·86	.....	.....	+ 0·08	.....	.....
						X + Y + 0·04	+ 0·17	+ 0·15	+ 0·12	.....	.....	+ 0·28	+ 0·06
		E				23 12·14	2 31·74	20 40·43	.....	+ 0·03	.....	.....	.....
1880-81 ...	5	W	$({}_2 10_1)$	$({}_1 8_2)$	$({}_2 9_1)$	12·24	31·72	40·64	.....	.....	− 0·12	.....	.....
						X + Y + 0·10	+ 0·02	+ 0·21	+ 0·11	.....	.....	− 0·09	+ 0·08
		E				31 3·62	2 31·74	28 31·75	.....	+ 0·13	.....	.....	.....
,, ...	6	W	$({}_1 14_2)$	$({}_1 8_2)$	$({}_2 11_1)$	3·32	31·72	31·81	.....	.....	+ 0·21	.....	.....
						X + Y + 0·30	+ 0·02	+ 0·06	+ 0·13	.....	.....	+ 0·34	− 0·04
		E				31 3·62	7 43·14	23 20·63	.....	+ 0·15	.....	.....	.....
,, ...	7	W	$({}_1 14_2)$	$({}_1 13_2)$	$({}_1 15_2)$	3·32	42·84	20·41	.....	.....	+ 0·07	9	.....
						X + Y + 0·30	+ 0·30	+ 0·22	+ 0·27	.....	.....	+ 0·22	+ 0·04
		E				16 28·09	7 43·14	8 45·06	.....	+ 0·11	.....	.....	.....
1882-83 ...	8	W	$({}_2 27_1)$	$({}_1 13_2)$	$({}_2 26_1)$	27·89	42·84	44·78	.....	.....	+ 0·27	.....	.....
						X + Y − 0·20	+ 0·30	− 0·23	− 0·06	.....	.....	+ 0·38	− 0·08
		E				26 22·88	1 30·03	24 52·77	.....	+ 0·08	.....	.....	.....
,, ...	9	W	$({}_1 20_2)$	$({}_1 21_2)$	$({}_2 24_1)$	23·10	30·56	52·67	.....	.....	+ 0·03	.....	.....
						X + Y − 0·23	− 0·53	− 0·20	− 0·32	.....	.....	+ 0·11	+ 0·03
		E				13 55·27	1 30·03	12 25·00	.....	− 0·24	.....	.....	.....
,, ...	10	W	$({}_2 23_1)$	$({}_1 21_2)$	$({}_2 22_1)$	54·98	30·56	24·63	.....	.....	− 0·21	.....	.....
						X + Y − 0·29	− 0·53	− 0·37	− 0·40	.....	.....	− 0·45	− 0·02
		E				33 37·78	24 52·77	8 45·06	.....	− 0·05	.....	.....	.....
,, ...	11	W	$({}_2 25_1)$	$({}_2 24_1)$	$({}_2 26_1)$	37·54	52·57	44·78	.....	.....	− 0·19	.....	.....
						X + Y − 0·24	− 0·20	− 0·23	− 0·24	.....	.....	− 0·24	+ 0·07

Note.—The subscripts 1 and 2 indicate positions of the instruments on each arc east or west of one another. Thus $({}_1 3_2)$ means, that on the arc (3) instrument No. 1 was at the west station, and instrument No. 2 at the east station.

255. Extracting the values of (X+Y) by Q.5 for each arc, year by year, we have from columns 7, 8, and 9—

Arc values of (X+Y).

1875-76.		1876-77.		1880-81.		1882-83.	
	s.		s.		s.		s.
(1) Gives	−0·04	(6) Gives	+0·15	(8) Gives	+0·02	(20) Gives	−0·22
(2) „	+0·05	(7) „	+0·04	(9) „	+0·21	(21) „	−0·55
(3) „	+0·13		+0·19	(10) „	+0·10	(22) „	−0·37
(4) „	+0·07			(11) „	+0·06	(23) „	−0·29 Q.11
(5) „	+0·17				+0·10	(24) „	−0·20
	+0·10			(12) „	0·00	(25) „	−0·24
				(13) „	+0·30	(26) „	−0·28
				(14) „	+0·30	(27) „	−0·20
				(15) „	+0·22		−0·29
					+0·27		

Where there is a marked increment from (13) onwards with the additional subsequent feature that the sign otherwise remarkably constant changes from +to—at (20).

256. The columns 8 to 14 are sufficiently explained in their headings, from which it will be seen that the values of X+Y in 10 and 13 are comparable theoretically in horizontal lines; the differences however are of too fluctuating a nature to admit of definite conclusions. But in the cases of columns 11 and 12, these show at least that X and Y (with one exception) are of the *same* sign; hence the residual under discussion *does change sign* on reversing pivots.

257. Again, in view of the decided increase in the residual after arc (12), as shown in Q.11, the results in columns 13 and 14 are *now* divided at that arc into two groups, and the averages taken *irrespective of sign*: contrasting these, it will be found—

Average (X+Y) from column 13...	Before arc (12)	0·18	
	After „ „	0·28	Q.12
Average ½ (X−Y) „ 14...	Before „ „	0·04	
	After „ „	0·05	

258. The first pair shows a similar increment as appears in Q.11: the second pair is practically of the most importance, for it represents circuit error from the mean of I. P. E. and I. P. W; this error, it will be seen in column 14, is never greater, on the average, in any one arc than 0″·08, and its average before and after arc (12) as shown above in Q.12 is small and practically the same, so that it has not increased, notwithstanding the growth of the facial residual.

259. The smallness of the circuit errors is no doubt a satisfactory fact; none the less, the locality in the instruments of the facial residual has been keenly sought for. The two changes made on reversing pivots, are (*a*) change of contact surfaces between pivot and Y; (*b*) reversing the transit wires and therefore the sign of their interval errors, if any. As respects (*a*), it is easy to account for the residual, on the assumption that the pivots have worn unequally only for positions of the telescope when pointing a few degrees north and south of the zenith, where in fact, it may be said, all the work is performed; but this reason fails to hold good in view of the sudden *change of sign* between 1880-81 and 1882-83 as shown in Q. 11. It was after the season of 1881-82, and therefore in the interval just mentioned, that the attachments of the telescopes to the cubes of the transit axes were opened out and strengthened, as already stated, but there is no reason to suppose that the figures of the pivots were altered in the remotest degree on this occasion.

260. The observations of the ensuing season will be taken with both similar and dissimilar pivots, and otherwise also the measurements will admit of determining the residuals for *each* telescope at each station, so that the facial difference may be removed.

261. Instrument No. 2 was carefully examined by Mr. Hennessey, Officiating Deputy Surveyor-General in charge Trigonometrical Branch, at Calcutta while set up and in use on the arc to Akyab, but no cause for the residual was detected.* Experiments were also made to try and measure the discrepancy by means of a striding level, but the levels were not sufficiently sensitive, their cradle suffered from torsion, and want of sufficient time brought the experiments to a close without result.†

262. The officers of the Telegraph Department have, as usual, co-operated cordially in the longitude operations.

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* Though I failed actually to detect the exact seat of the residual, I have a strong suspicion that, apart from pivot imperfections, if any, the locality lies in the Y blocks. These are not *fixed* as is commonly the case; each *Y in block* may be regarded as the central slice cut of a hemisphere, slotted through and connected loosely by a pin to a similar concave *fixed* socket; thus the lower surface of each Y block is spherical and provides a universal joint within the limits of the pin's slot, hence though the Y *blocks* cannot move in any other direction, when the instrument rests on them, they certainly have a tendency to *minute rotation in the meridian, when the telescope is rotated*, depending on the weights of the blocks, the friction and cohesion between the Ys and pivots, &c.; and this of course would vary the inclination of the transit axis to the normal. Obviously, means should be provided for rigidly clamping (and also for releasing) the *Y blocks* at will.—J. B. N. H.

† Major Strahan reports of Mr. Keelan that "his work both in the field and recess has been quite satisfactory," and of his office writer Harsahoi, that "he performed his duties very efficiently."

Major Heaviside reports, "Mr. D. Atkinson only joined the party on 3rd of August; he has performed his recess duties most satisfactorily." Of his observatory recorder and computer, he says "Dhondo Balwant Joshi has performed his duties satisfactorily."

PART II.

THE OPERATIONS AT THE SEVERAL HEAD-QUARTERS OFFICES.

THESE offices comprise—

(1) The Survey of India Offices at Calcutta.
(2) The Trigonometrical Branch Office at Dehra Dun.

263. The first of the new buildings erected at Calcutta for the accommodation of this department was occupied towards the close of the year 1882, as mentioned in General Walker's last report. The administrative offices having thus been brought under one roof, a Committee was appointed by General Walker to formulate a scheme for the closer amalgamation of such sections of the office as were employed on similar work, but which, from their having been previously located in separate buildings, had necessarily been worked separately and under different management. It was thus hoped to ensure greater efficiency and more uniformity in procedure; a result very desirable since the general amalgamation of the three different branches of the department—the Trigonometrical, Topographical, and the Revenue. Acting upon the report of the Committee, it was decided to amalgamate the correspondence and accounts offices of the Surveyor-General's Office and the Revenue Survey Office, under one Registrar, and form

Personnel.

Major G. Strahan, R.E., Deputy Superintendent, 2nd grade, from 27th April to 24th July 1883.
Major R. V. Riddell, R.E., Deputy Superintendent, 2nd grade, up to 19th April 1883.
Major C. Strahan, R.E., Deputy Superintendent, 3rd grade, officiating in 2nd grade from 24th July 1883.
J. O. N. James, Esq., Deputy Superintendent, 3rd grade, officiating in 2nd grade, up to 30th April 1883.
Major J. E. Sandeman, S.C., Deputy Superintendent, 3rd grade, up to 30th September 1883.
Major M. W. Rogers, R.E., Deputy Superintendent, 4th grade, officiating in 3rd grade, from 19th April 1883.
Captain St. G. C. Gore, R.E., Assistant Superintendent, 1st grade, officiating Deputy Superintendent, 3th grade, from 13th December 1882.
H. Duhan, Esq., Personal Assistant up to 30th March 1883.

DRAWING OFFICE.

Section I.—(Miscellaneous Drawing and Compiling.)

Mr. W. H. Patterson, Chief Draftsman, up to 21st January 1883.
Mr. A. Chamarett, Chief Draftsman, from 22nd January 1883.
Mr. F. W. Kelly, Head Draftsman, up to 21st February 1883.
Mr. S. M. Smylie, Head Draftsman, from 12th March 1883.
Mr. J. A. May, Surveyor, 2nd grade.
„ W. Green Draftsman.
„ J. R. Adels „
Munshi Sumaullah „
„ Nabi Buksh „
Mr. A. J. Musgrove „
Baboo Hurrihur Sen „
„ Mohesh Chunder Shaw „
Mr. R. C. Sinclair „
„ W. P. Smith „
and 27 others.

Section II.—(Boundary Record and Colouring.)

Mr. J. Connor, Assistant Surveyor and Draftsman, and seven others.

Section III.—(Map Examining and Compiling, &c.)

Mr. J. McGill, Surveyor, 1st grade.
„ W. Todd „ 2nd „
„ A. J. Wilson „ 2nd „
„ F. Adams „ 2nd „
Baboo Purna Chunder Sen, Draftsman, and three others.

Cadastral Map Examining.

Mr. W. Sinclair, Surveyor, 2nd grade (on furlough, retired from 23rd September 1883).
Mr. J. H. O'Donel, Surveyor, 4th grade.
„ R. C. D. Ewing, Assistant Surveyor, 1st grade, and seven others.

ENGRAVING OFFICE.

Mr. C. W. Coard, Superintendent.
„ W. Donaldson.
„ G. C. Palmer.
„ D. L. Mitchell.
„ J. Fulford.
„ T. B. Rogers.
„ A. G. Palmer (on deputation).
„ S. M. Coard.
„ A. W. N. James.
„ A. R. Coard.
„ A. D. M. Chamarett.
„ E. A. Ollenback
25 Native Engravers, and 1 Clerk.

Copperplate Printing Section.

Mr. W. T. Collins, Copper-plate Printer, 13 Native Printers and Pressmen, &c.

CORRESPONDENCE OFFICES.

Section I.—Correspondence.

Mr. T. W. Babonau, Registrar and Accountant.
Mr. A. C. Cunningham.
„ M. Francis.
„ F. A. DeRozario.
„ T. E. Ware.
Baboo Kalipodo Banerji.
„ Bani Madhub Banerji.
„ Doorganarain Ghose.
Mr. J. A. Vallis.
Baboo Ram Kristo Chunder.
„ Bheecum Singh, and 12 others.

Section II.—Accounts.

Mr. Gopal Chunder Laha.
„ E. D. Algar.
Baboo Bama Churn Chuckerbutty.
„ Rajkrishna Mookerjea, and four others.

MAP RECORD AND ISSUE OFFICE.

Mr. A. E. Byrn, Head Assistant.
„ R. A. Gibson, Map Curator, up to 4th September 1883.
Mr. P. C. H. Smart, from 15th September 1883.
Mr. B. M. Wilson, Assistant Surveyor.
„ H. R. Vallis.
„ W. P. Abro, and four others.

three sub-offices—the Surveyor-General's Office, the Revenue Branch Office, and the Topographical Branch Office, each under the immediate supervision of its own head clerk. In practice it has been found desirable that the accounts of the Revenue and Topographical Branches should remain under the supervision of their respective Deputy Surveyors-General, although the clerical establishment is classed in an amalgamated list.

264. It was also decided to bring together the drawing offices of the Surveyor-General's office and that of the Revenue Survey Office under one Assistant Surveyor-General.

265. The work of the Drawing Office divides itself so distinctly into two classes—the geographical drawing and that connected with large-scale revenue maps—that it has been found advisable to keep up two sections of the office to deal with the two classes of work, although, for administrative purposes, the clerical staff are all amalgamated in one list. Very considerable advantage in uniformity has already been derived from the general control being vested in one officer.

266. The various offices thus collectively classed as the Calcutta offices of the Survey of India Department are now therefore—

(1) The Surveyor-General's Office.
(2) The Topographical Branch Office.
(3) The Revenue Branch Office.
(4) The Map Record and Issue Office.
(5) The Drawing and Engraving Offices.
(6) The Lithographic Office.
(7) The Photographic Office.
(8) The Mathematical Instrument Office.

267. The duties of the Surveyor-General's Office and the Topographical Branch Office were supervised by Major R. V. Riddell, R.E., up to the 19th April, when that officer took up the duties of Mint Master at Bombay: for the remainder of the year under notice the work has been carried on under Major M. W. Rogers, R.E.

268. The Revenue Branch Office has been supervised by Colonel Sconce, the Deputy Surveyor-General in charge of Revenue Surveys, who has carried on all the duties connected with the accounts as well as the correspondence of the branch. Major J. E. Sandeman, Deputy Superintendent, assisted in this office from 4th November 1882 to 30th September 1883.*

Map Record and Issue Office.

269. The following statement shews the amount of work done by the Map Record and Issue Office:—

Maps issued.		Number.	Value. Rs.	A.	P.
General maps to Government officials	...	40,584	51,366	14	0
Ditto India Office, London	...	1,647	3,108	8	0
Ditto through agents	...	7,141	9,952	8	0
Total	...	49,372	64,427	14	0
Cadastral maps to Government officials	...	179,805	1,34,853	12	0
Grand totals	...	229,177	1,99,281	10	0

* Mr. Babonau, as Registrar, has carried out his duties zealously and well.

In the Surveyor-General's Office, and the Topographical Survey Office, Messrs. Francis, D'Rozario, and Algar, and Baboos Bani Madhub Banerji, Durga Narain Ghose, and Chuni Lall Dey deserve special commendation.

Colonel Sconce, Deputy Surveyor-General in charge of the Revenue Branch, remarks on his Office establishment as follows:—

Mr. A. C. Cunningham, Mr. Gopal Chunder Laha, Baboos Kali Pado Banerji, Ram Kisto Chunder, and Bama Churn Chuckerbutty, with the rest of the clerks, have given satisfaction.

The number of applications received for extracts was 489, for copying of which Rs. 4,567 were received and paid to the copyists.

	Rs.	A.	P.
Amount realised and paid into Government treasuries from resident agent	3,184	0	6
Amount realised and paid into Government treasuries from mofussil agents	1,104	15	6
Total ...	4,289	0	0

N. B.—Messrs. Thacker, Spink & Co., Calcutta, and Messrs. Williams, Simla, have not submitted their accounts for the past year.

	Rs.
Applications received for maps by letters, indents, and telegrams...	3,026
Letters issued in reply, and as advices of despatch	1,482
Invoices and receipts issued	2,254
Packets, parcels, and town despatchs	3,853
Sheets coloured for sale and issue	20,830
Ditto other departments	6,800

270. From the above statement it will be seen that the total value of maps issued amounted to very nearly two lakhs of rupees, of this, only about Rs. 6,000 (allowing for the amount due from two agents) have been really paid into Government treasuries, the remainder, viz. upwards of Rs. 1,93,000 being on account of maps supplied on Government service.

271. The first two items, viz. general maps issued to Government officials and to the India Office shew an apparent decrease on those of last year, although a very great increase on all previous years. This is partly due to the fact that in former returns an issue of a map of six sheets has been entered as one of six maps; this did not appear to be a proper way of computing them, and has been discontinued; another reason for the decrease in the first item is, that the maps which are required for purposes of compilation, &c., in the drawing and other offices, have not been added in with those issued on Government service, as has been done hitherto; it is estimated that this would represent some 3,000 sheets extra. These two reasons account, or nearly account, for any apparent diminution in the issue of general maps on service. It may be noted that their value is in excess of those of last year, and as there is no evidence to shew that the individual price of maps has increased, it is reasonable to suppose that the number issued has also increased, and not decreased.

272. The arranging and sorting of originals is still being steadily proceeded with, and a few months will, it is hoped, see it completed. The sorting and cataloguing of printed maps has been found to be a very long and heavy job, and it was impossible for the map curator to do it in addition to his other duties; help has now been given to him, but even with this it will probably be not less than three years before the map office will be really in thorough order.

As a proof of this growth of the work in this office, I may state that in 1879-80 the Map Curator issued 30,571 maps to Government officials and to the public generally, against 47,725 in this year—an increase of more than half as much again.*

Drawing Office.

273. Since the Surveyor-General's and Revenue Survey Offices have been brought together into one building, the two drawing offices have been under one Assistant Surveyor-General, an experienced draftsman supervising the work in each. In the first section, that which was originally attached to the Surveyor-General's Office, besides the usual work of compiling and correcting maps of India, provincial and district maps on various scales, several special maps were prepared for exhibition, such as those shewing

* In consequence of the great increase of work in the Map Issue Office it was found necessary to place the despatch of maps under Mr. A. E. Byrn, who has done much to simplify the office routine and put it on a good footing.
Mr. R. A. Gibson, who had performed the duties of Map Curator most efficiently for over three years, was transferred to a Field Party in November, his place being taken by Mr. P. C. H. Smart.

distribution of crops and forest trees, the trade routes to and from India, lines of telegraph, canals, and several others. A new compilation in two sheets of the North-West Provinces, on the scale of 16 miles = 1 inch, has been commenced; this will eventually be engraved. A map on the same scale of the Nizam's dominions in Hyderabad is also in course of preparation, the best materials available being utilised, and based on the modern system of triangulation. It is intended that this map shall be photo-zincographed and published in outline, and subsequently lithographed with hills. A similar map of the Punjab has been completed, and its publication is only delayed until the Punjab Government return the proofs sent them, with the latest corrections in boundaries, &c. Another 16-mile map will include Guzerat, Kattywar, and Cutch, and is also in progress. Twelve provincial maps, on the scale of 80-miles = 1 inch, and seventy-seven district maps on scales of either 8 miles or 16 miles to the inch have also been prepared for administration reports; the preparation of these maps having been asked for all at once and urgently, has been a heavy job, and has somewhat interfered with current work; in many cases too, the results are not good, for no time being allowed for preparing them properly, extracts had to be taken from old maps on half worn out lithographic stones. If a regular supply of these maps is to be kept up, they should be engraved on copper, the plates being kept as standards on which the latest additions and corrections can be made from time to time. A complete series of provincial Index maps for the whole of the country dealt with by the Survey of India Department is also in preparation; these will gradually supersede the old local Index maps of survey parties, so that eventually the whole country will be divided up into sheets of standard size, viz., 30 minutes of longitude by 15 minutes of latitude, numbered by provinces.

The drawing and reducing of original survey work for the atlas sheets has been regularly carried on, as fast as materials came in.

274. In the second section—the old Revenue Survey Drawing Office—all standard maps on scales of 4 inches, 2 inches, and 1 inch = 1 mile, received from executive officers are examined and passed on to be photo-zincographed and published. The compilation of old survey work into standard sheets on the 1-inch scale is also undertaken in this office. In this way 34 out of 44 standard sheets in the districts of Bannu, Dera-Ismail-Khan, and of Muzuffargarh have been published, whilst others are in hand. The districts of Moradabad, Budaun, Tarai, and part of Rampur, as well as Banda are all being prepared in the same way, and are in an advanced state. The district of Julpaiguri, in 13 sheets, is complete, and is only awaiting the final orders of Government with respect to thana boundaries. Three special maps of India were also prepared for the Calcutta Exhibition in this section. For all the miscellaneous work of traces and supply of traverse data, examination of computations, &c., &c., see table at page 61 of the Appendix. A return of all the cadastral maps passed through this office and published will also be found at page 63 thereof.*

Examining Office.

275. The work done by this office will be found in detail at page 62 of the Appendix. Forty-six standard sheets, large scale plans, and triangulation charts of topographical surveys; fifty-seven compilations for atlas sheets, and one hundred and fifty engraved proofs were compared with the originals, besides upwards of two hundred photographed and lithographed proofs. Thirty-one atlas sheets were projected, besides a considerable amount of miscellaneous work.†

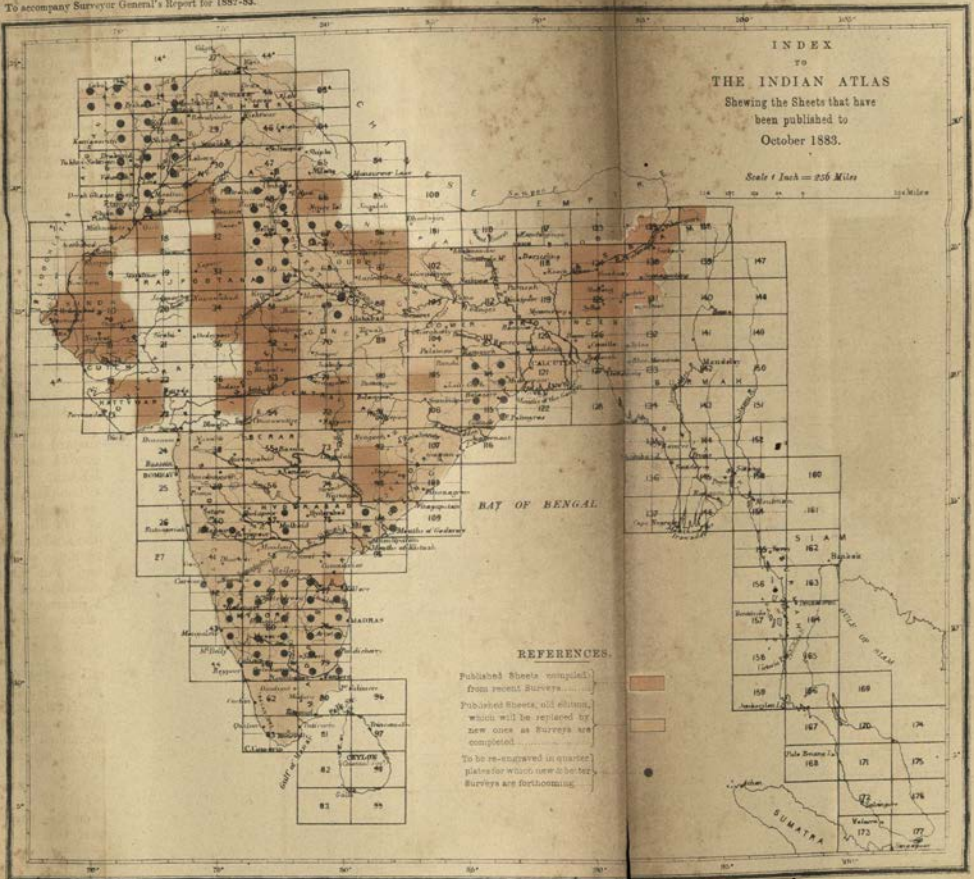
Engraving Office.

276. In consequence of sickness necessitating leave on the part of several of the European engravers and of some of the natives, the out-turn

* Messrs. A. J. Wilson, J. H. O'Donel, and J. Connor were all transferred at the beginning of the field season to Survey Parties, and in their stead Mr. E. P. S. Hill only has as yet been appointed. The Drawing Office has therefore been very short handed, and some little difficulty has been found in keeping pace with the current work. Both Messrs. Chamarett and Smylie, in charge of the two sections of the Drawing Office respectively, have done excellent work.

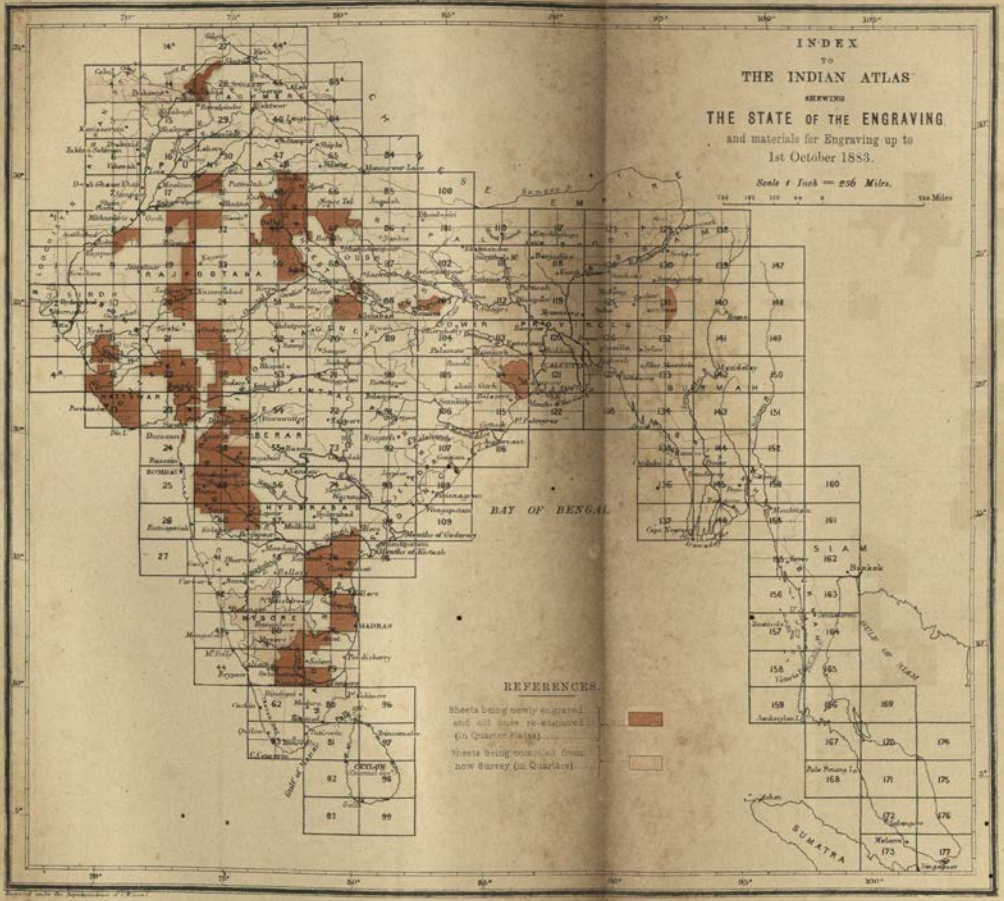
† From January Mr. McGill was in charge of the Examining Office; all the duties of which he has performed most satisfactorily.

To accompany Surveyor General's Report for 1882-83.


INDEX
TO
THE INDIAN ATLAS
Shewing the Sheets that have been published to
October 1883.
Scale 1 Inch = 226 Miles
BAY OF BENGAL
REFERENCES.
Published Sheets compiled from recent Surveys.
Published Sheets, old edition, which will be replaced by new ones as Surveys are completed.
To be re-engraved in quarter plates for which new & better Surveys are forthcoming.
SIAM
SUMATRA
GULF OF MANAAR

Published under the direction of Colonel H. C. Tanner, R.E., Officiating Surveyor General of India.
Survey of India Office, Calcutta, February 1884.

To accompany Surveyor General's Report for 1882-83.



Published under the direction of Colonel H. C. Dalton, R.E., Officiating Surveyor General of India.
Survey of India Offices, Calcutta, January 1884.

in hill etching and outlining is less this year than last year. Steel-facing to protect the copper plates has been carried on with great success; this year nearly three times the number of plates having been thus treated, compared with those of last year. The work of the copper-plate printing office has very greatly increased, and as more atlas sheets and other engraved maps are published, must continue to increase. 15,114 impressions were taken, of which 1,503 were proofs and 282 were transfers for putting on to stone; last year's total was only 8,967. Two small presses have been lately sent out from England, and materially assist by taking a great deal of the printing of the small plates; but even with these, copies cannot be turned out fast enough to keep pace with the demand.

277. The tables at pages 64 to 67 of the Appendix shew the exact amount of work done during the year. Progress has been made in the standard map of India, scale 32 miles = 1 inch. Sheets 5 and 6 in Madras and Burma are now complete, whilst the hills in the Bengal Sheet No. 4 are being etched. Two other sheets are steadily progressing. The 64-mile map of India will be published almost immediately. The map of the Central India Agency is now very nearly complete, whilst that of the Rajputana Agency has still a considerable portion of the Bikanir desert blank; this is all being filled in as materials are supplied. Seven quarter-atlas sheets, marginally noted, have been completed, whilst thirty-nine atlas sheets are now in progress, and twenty-six have been repaired, corrected, and added to. The total out-turn of engraving work is as follows:—1,607 square inches of hill etching, 312 square inches of jungle etched, 2,844 square inches of outlining, and 225,771 letters cut.

8 N.E.	66 S.W.
13 N.E.	71 S.E.
31 S.W.	138 S.W.
31 S.E.	

LITHOGRAPHIC OFFICE.

278. Major Riddell was in charge of this office until the 19th April 1883, when he made over charge to Major Waterhouse.

279. The number of maps, plans, drawings, &c., published during the year amount to 735, of which 465 (in 471 sheets) were executed for other departments and only 264 (including departmental forms) for the requirements of the Survey Department.

Personnel.

Major R. V. Riddell, R.E., in charge up to 19th April 1883
Major J. Waterhouse, S.C., in charge from 19th April 1883.
Mr. H. L. Lepage, Head Assistant, on furlough from 24th July 1883.
„ Alfred Palmer, Officiating Head Assistant from 24th July 1883.
Baboo Baloram Nath.
Munshi Mahomed Azim.
„ Subhan Buksh and 25 others.
Mr. J. Watson, Officiating Chromo. Printer, one Press Assistant, and 70 others.
Mr. E. DePyvah, Type Printer, and 23 others.
Three clerks, and others.

280. Amongst the new maps, seven 1-inch scale sheets of Oudh, comprising the districts of Fyzabad, Unao, Lucknow, Sultanpur, Rae Bareli, and Bara Banki, have been re-drawn (for second edition) during the year, but not yet printed. Six are in the hands of the draftsmen, and nine sheets, comprising the districts of Partabgarh, Rae Bareli, Hardoi, Lucknow, Unao, Bahraich, Fyzabad, and Sultanpur, which were drawn previously, have been printed off. The remaining portion of the 1-inch sheets of district Noakholly have been completed and printed. Twenty-four different maps of various scales, including the following district maps, 1 inch = 4 miles:—Bancoorah, Rajshahye, Chittagong (two sheets), Naga Hills, and Hooghly, have been compiled from transfers from copper-plate with additions and corrections on stone.

281. From other departments 465 subjects, comprised in 471 sheets, were received for publication, and the value of the work performed, Rs. 22,767, shews a considerable increase over previous years.

282. The most important of the extra departmental maps are the Irrigation map of the North-West Provinces, scale 1 inch = 8 miles, drawn in four sections, and printing in three colours nearly completed; and the Rainfall Chart of India, on the scale of 64 miles = 1 inch, which was almost completed and ready for printing at the end of the year. For this map an entirely new series of ruled tint plates were engraved, in order to give the requisite strength to the gradation for eight shades of colour, obtained by two printings. The result has been exceedingly successful.

* Mr. A. G. Palmer was transferred to the Lithographic Office in July. The Superintendent, Mr. C. W. Coard, and his European and native assistants continue to perform their duties in their usual artistic style.

283. A machine for making rubber stamps has been taken over from the Mint, and has proved useful in making up stamps for departmental use.*

THE PHOTOGRAPHIC OFFICE.

284. The out-turn of the Photographic Office is given in the annexed abstract. The amount of work done for the Survey and other departments shews an increase generally all through; although the number of original subjects received for reproduction was not quite so great as in the year before. On the cadastral side, the number of sheets reproduced by photography was somewhat smaller, but the total number of sheets zincographed and photo-zincographed was greater by 174; and the number of copies printed 19,379 more than last year.

Personnel.

Major J. Waterhouse, B S.C., Assistant Surveyor-General, in charge.

NEGATIVE SECTION.

Normal Establishment.

Mr. A. E. Caddy (offg.) Photographer
„ C. DeCruze, Asst. „
Ismail Khan „ „
2 negative re-touchers, 2 glass-cleaners, and 1 bhisti.

Cadastral Establishment.

Mr. C Marshall, Photographer.
„ L. Lagnier „
„ T. Lloyd Asst. „
4 Assistant Photographers, 3 negative re-touchers, 4 glass-cleaners, and 1 bhisti.

PHOTO-TRANSFER PRINTING.

Normal Establishment.

Mr. J. Harrold, Photographer.
Habibul Hossain, Asst „
2 labourers.

Cadastral Establishment.

Mr. R. George, Photographer,
2 Assistant Photographers and 4 labourers.

SILVER-PRINTING SECTION.

Normal Establishment.

Mr. G. G. Dempster, Photographer.
2 Assistant Photographers and 2 labourers.

ZINC-PRINTING SECTION.

Normal Establishment.

Mr. B. Mackenzie, Zincographer, 1 writer, 4 zinc correctors, 5 printers, 4 sponge-men, 16 pressmen, and 3 grainers.

Cadastral Establishment.

Mr. J. Watson, Zincographer (on deputation to Litho. Office).
Mr. E. A. LeFranc, Zincographer, 1 writer, 8 zinc correctors, 7 printers, 4 sponge-men, 15 pressmen, and 6 grainers.

GENERAL-OFFICE ESTABLISHMENT.

Normal Establishment.

Baboo Kanny Lall Sen, Storekeeper and Accountant.
Mr W. Moore, clerk, from 15th September 1883, and one native clerk.

Cadastral Establishment.

Mr. J. Mackenzie, (offg. head assistant) and one clerk.

285. Statements shewing the comparative out-turn of the different sections of the office during the present and past year, of expenditure and value of work done, and of work done for other departments, are given in the appendix.

286. The value of the printed maps and other subjects issued during the year has been—

	Rs.
Departmental	42,415
Extra departmental	22,071
Cadastral	75,266
Other receipts	3,947
Total ...	1,43,699

The expenditure for establishment and stores has been Rs. 97,436, so that the profit to credit of the department amounts to Rs. 46,263.

287. The work done during the year for the Survey and other departments calls for no particular remark, and has been of the usual miscellaneous character.

The number of cadastral maps printed off and issued during the year was 5,216, which is 360 more than last year.

288. As the house occupied by the office, No. 1, Wood Street, was becoming inconveniently crowded, and there was an immediate want of more accommodation for presses for printing off the cadastral maps, No. 2, Wood Street was secured on a three-years' lease, and will suffice to give all the additional space likely to be required for the office until the new Photographic and Lithographic Offices are built.

289. The heliogravure process has made steady progress during the year. Seven plates have been done, of which four were for the Geological Survey, one outline map of Simla and Jutog, and two plates of the view of Kin-chin-jinga, published with last year's annual report. More might have been done but for the untimely decease of Mr. W. E. Batho, the newly appointed Head Assistant, who was superintending that work. The number of plates turned out has, however, just kept pace with the power of the copper-plate printing

* Major Waterhouse reports favourably of the conduct of the European Assistants—Mr. H L. Lepage, Head Assistant, Mr Alfred Palmer who officiates for him, and Mr. J. Watson, officiating as Head Printer. Mr. DePyvah, Type Printer, and the native draftsmen and clerks have also worked well.

branch to print. Two plates are now in hand, the award certificate for the International Exhibition, and a plate of a piece of granite for the Geological Survey.*

Abstract of Work performed in the Photographic Office, Survey of India Department, from 1st October 1882 to 30th September 1883.

	Original sections or sheets.	Negative plates.	Photographic transfer prints.	Number of plates.	Number of pulls.	Number of printed sheets of each subject. Single.	Number of printed sheets of each subject. Combined.	Silver and other prints.	Cost. Rs. A. P.
Topographical survey maps	128	238	196	80	8,907	9,567	9,492	172	4,944 2 8
Revenue survey maps...	290	529	549	241	38,373	38,373	34,123	.....	15,454 1 11
District maps	6	28	28	3	550	550	550	.....	377 6 9
General maps	22	78	83	37	3,738	3,848	3,413	.....	1,868 3 0
City and cantonment plans	15	60	60	16	2,740	2,740	2,590	.....	1,172 0 2
Miscellaneous departmental	249	506	416	214	14,599	16,164	13,721	101	8,011 10 4
Ditto extra departmental	387	601	605	386	28,593	230,612	222,896	311	16,641 10 7
Transfers and proofs	.....	.....	.....	.....	2,575	.....	.....	.....	.....
Zincographs	55	.....	.....	.....	.....	.....	.....	.....	.....
Total ...	1,152	2,040	1,937	977	129,984	301,894	286,783	584	48,469 3 5
Cadastral, North-West Provinces.									
Photo-zincographs	1,209	1,209	1,200	1,169	11,690	11,690	6,480	.....	17,975 9 0
Zincographs	786	.....	.....	786	7,925	7,925	6,935	.....	8,175 6 0
Total ...	1,995	1,209	1,200	1,955	19,615	19,615	13,415	.....	26,150 15 0
Cadastral, British Burma.									
Photo-zincographs	1,749	1,749	1,841	1,861	62,158	62,158	25,720	.....	30,262 8 0
Zincographs	847	.....	.....	847	28,798	28,798	13,430	.....	9,485 15 0
Total ...	2,596	1,749	1,841	2,708	90,956	90,956	39,150	.....	39,748 7 0
Cadastral, Bengal.									
Photo-zincographs	504	504	588	493	18,074	18,074	5,055	.....	8,894 2 0
Zincographs	18	.....	.....	18	724	724	724	.....	247 8 0
Total ...	522	504	588	511	18,798	18,798	5,779	.....	9,141 10 0
Transfers and proofs for cadastral maps...	.....	.....	.....	.....	10,242	.....	.....	.....	.....
Cadastral maps, total ...	5,113	3,462	3,629	5,174	139,610	129,369	58,344	.....	75,041 0 0
GRAND TOTAL ...	6,265	5,502	5,566	6,151	269,594	431,263	345,129	584	1,23,510 3 5

MATHEMATICAL INSTRUMENT OFFICE.

290. During the financial year 1882-83 the work of this office has steadily increased, the issue of instruments to various departments has been slightly greater than in former years, whilst the number of instruments repaired for public officers, and also of those repaired and rendered fit for future issue, has greatly exceeded the former average, there being a gradually increasing demand on the workshops for repairs owing to the increase of work in India.

Personnel.

Major R. V. Riddell, R.E., from 1st April to 3rd October 1882 and from 18th to 31st March 1883.
Major J. Waterhouse, S.C., from 4th October 1882 to 22nd January 1883.
Lieutenant-Colonel W. M. Campbell, from 23rd January to 12th March 1883.

Workshop Branch.

Mr. T. Bolton, Mathematical Instrument-maker.
Mr. F. Marshall, Assistant Mathematical Instrument-maker.
64 artificers on the permanent establishment.
91 (on an average) artificers on the temporary establishment.

Store Branch.

Mr. G. R. Alderman, Instrument-storekeepr.
Babu Womesh Chunder Chowdhry, Material-storekeeper.
1 Packing sircar.
2 Packers.

Office Establishment.

Mr. M. O'Brien, Head Clerk.
„ J. W. Collins, from 1st April to 5th June 1882. } 2nd clerk.
Mr. C. O. Gray, from 14th June 1882 to 31st March 1883. } 2nd clerk.
6 other permanent clerks.
1 extra clerk.

291. As these repairs are the most important employment of the establishment, their increase necessitates a corresponding diminution in the manufacture of new instruments, which is only carried on when any portion of the workmen can be spared from repairs.

The stock of instruments was increased by a total receipt of 19,784 instruments, amounting in value to Rs. 1,09,623, the detail of which is as follows:—6,211 instruments, in value about Rs. 20,600 were received from England; 982 were locally purchased at a cost of Rs. 6,731; 8,346 were manufactured in the workshop at a cost of about Rs. 15,763; 4,245, valued at Rs. 66,529 were received by departmental exchange, of which 1,372 were serviceable and 2,873 were

* Major Waterhouse reports favourably of his European Assistants, Messrs. J. Mackenzie, B. Mackenzie, J. Harrold, C. Marshall, R. George, L. Lagnier, A. E. LeFranc, and G. G. Dempster, and of his Head Clerk Baboo Kanny Lal Sen, who have worked with their usual zeal and steadiness.

repairable. Further, 3,735 instruments, forming part of the repairable stock, were repaired on the premises and rendered fit for future issue, at a cost of Rs. 23,070, which, after repair, were valued at Rs. 74,225. The number of instruments repaired for store this year exceeded last year by 885; the cost of repairs being Rs. 10,770 greater than last year.

292. More than 21,100 instruments, valued at about Rs. 1,27,500, were issued during the year to various departments, as under:—

	Number.	Value.
		Rs.
Survey of India Department	7,860	33,810
„ Marine „	60	530
Telegraph „	10	470
Military „	610	4,700
Public Works „	5,190	59,370
Educational „	130	750
Miscellaneous „	5,350	19,180
Road Cess Committees, District Engineers, &c., entitled to receive instruments on payment when available	820	4,560
Workshop to complete repairs of instruments ...	1,070	4,110
Total ...	21,100	1,27,480

293. The total number of instruments issued was slightly greater than in the two previous years. Their value, however, was less than last year, when an exceptional number of expensive instruments were purchased and issued to the railway surveys. The average number of theodolites and levels issued annually during the years 1879 to 1882, was 91 for the former and 118 for the latter instruments. During the year under report, the numbers were respectively, 100 and 131, and more could have been issued if they had been available.

294. The number, class, and cost of the principal instruments purchased, were as follows:—

Designation of Instrument.	No.	Cost.
		Rs.
Barometers, aneroid	3	220
Glasses, binocular	15	807
Instruments, drawing, in cases	3	255
Levels, dumpy	2	105
Rules, parallel, brass	6	225
Scales of various sorts	75	414
Set-squares, in sets	47	517
Theodolites	2	975
Tapes, measuring	94	440

295. The chief articles manufactured in the workshop, and the cost of their manufacture, were as under:—

	No.	Cost.
		Rs.
Boards, drawing	19	229
Chains, measuring	149	1,583
Clinometers	50	460
Compasses, magnetic, for plane-tables	43	516
Glasses, tracing	4	147
Levels, field service	12	300
Machines, map printing	24	1,320
Pins for measuring chains	1,666	371
Plane-tables	77	723
Pluviometers	60	1,200
Rules, parallel, bar, electrum	30	418
„ sight, for plane-tables	65	424
Scales, card-board	3,014	470
Staves, leveling	97	1,916
Stands for various instruments	71	986
Cases, packing	672	2,983

296. The total number of instruments repaired in the workshop was 5,500, being 1,100 more than in the previous year. The cost of repairs was

Rs. 38,400, being about Rs. 12,000 in excess of last year. The principal instruments repaired were as follows, viz.:—

Anemometers	5
Arithmometers	2
Barometers	56
Chains	584
Compasses, magnetic	61
Ditto, prismatic	58
Ditto, surveying	161
Glasses, binocular	17
Instrument-boxes, 1st, 2nd, and 3rd sort	184
Levels, dumpy, &c.	148
Plane-tables	130
Rules, flat, parallel and sight	64
Range-finders	21
Squares, optical	207
Sextants	4
Stands for various instruments	499
Staves, leveling	156
Tapes	40
Telescopes	49
Theodolites	144

The number of instruments repaired was about 25 per cent greater than last year, the increase being general. The number of theodolites and levels, which require the greatest care and good workmanship, being 292 against 274 last year, when the number was considered exceptionally great.

297. The system of local manufacture mentioned in paragraph 288 of last year's report was still further expanded; plane-tables were manufactured, and also the frame work for the new pattern clinometers for the Survey Department. The constant and steady increase of the amount of work under the head of repairs, whilst the establishment remains stationery, is rendering the development of this system necessary, and as all work done for the department is submitted to very careful investigation by the Mathemetical Instrument-maker, the result of our demands is to greatly improve the work of native artificers.

298. The profit-and-loss account of the workshop shews a profit of Rs. 2,647, the charges having amounted to Rs. 51,685, whilst the value of the work done was calculated at Rs. 54,332. Last year a profit of Rs. 300 was shewn. The increased profit shewn this year is due, probably, to a slight over-estimation of percentages on supervision of work done. The general average of several years shews, however, that the rate charged is very nearly correct.

299. The cost of the remaining portion of the establishment, including supervision, packing-expenses, office accommodation, &c., was about Rs. 17,908, which may be considered as representing the expenses connected with the receipt and issue of about 40,884 instruments, valued at about Rs. 2,37,123.*

THE TRIGONOMETRICAL BRANCH OFFICE, DEHRA DUN.

300. The principal work of this office is the final reduction and publication of the triangulation of all parts of India, including the principal and secondary operations of the Great Trigonometrical Survey, and also the publication of the Topographical Surveys executed by the Trigonometrical Branch of the department, as well as by Forest Surveys. Most of the publications

Personnel.

J. B. N. Hennessey, Esq., M.A., F.R.S., Deputy Superintendent, 1st grade, in charge up to 11th February 1883, and thereafter Officiating Deputy Surveyor-General, in charge Trigonometrical Branch.

W. H. Cole, Esq., M.A., Deputy Superintendent, 4th grade, acting as Assistant up to 11th February 1883, and thereafter officiating in charge.

Computing Branch.

Mr. C. Wood, Surveyor, 2nd grade.
„ H. W. Peychers „ 4th „
Baboo Ganga Pershad, Computer.
„ Cally Mohan Ghose „
„ Kally Coomar Chatterjee, Computer, and 10 other Computers, &c.

Printing Branch.

Mr. B. V. Hughes, Printer,
12 Compositors and Apprentices.

Correspondence, Stores, &c.

Mr. H. R. Duhan, Surveyor, 1st grade, and Personal Assistant to the Surveyor-General up to 1st April 1883.
Mr. J. Bond, Assistant Surveyor, 1st grade.
2 Native Writers.

Photo-zincographic Branch.

Mr. C. G. Ollenback, Zincographer.
„ C. Dyson, Photographer.
2 Native Draftsmen.
1 Do. Assistant-Draftsman.
1 Do. Map-keeper.

* The supervision of the workshop was ably carried on by Mr. T. Bolton, the Mathematical Instrument-maker, assisted by Mr. F. Marshall, the Assistant Mathematical Instrument-maker; the Storekeepers and the office establishment have also worked to the best of their ability.

Drawing Branch.	*Solar Photography.*
Mr. G. W. E. Atkinson, Surveyor, 2nd grade.	Mr. L. H. Clarke, Surveyor, 2nd grade, and Solar Photographer.
„ H. Sindon, and 15 other Draftsmen and Assistant Draftsmen.	„ C. F. Guthrie, Assistant to Solar Photographer.
8 Map Colourists.	

being necessarily of a technical nature, and the office being located at Dehra Dún, at a considerable distance irom Calcutta, it has small drawing, photo-zincographing, and printing estabishments of its own; it is thus independent of all extraneous assistance in publication, excepting as regards book-binding which is done mostly at Calcutta. The office has also a depôt of instruments and stores attached to it, chiefly of the higher class of instruments appertaining to the Great Trigonometrical Survey, of which it was long the head-quarters office. It had for many years been under the immediate superintendence of Mr. Hennessey, M.A., F.R.S., aided by Mr. Cole, M.A., but this arrangement underwent modification when General J. T. Walker, C.B., R.E., F.R.S., Surveyor-General of India, and Superintendent, Trigonometrical Surveys, left India on leave, 12th February 1883.

301. Mr. Hennessey was then appointed Officiating Deputy Surveyor-General, in charge of the Trigonometrical Branch,* and Mr. Cole was placed in officiating charge of the office, which was strengthened by transfer only to the extent of one native writer. Thus thorough amalgamation and co-operation between the administrative and executive offices became necessary. Mr. Hennessey continued to supervise certain professional operations which would have fallen to Mr. Cole had the latter an assistant as usual. On the other hand, Mr. Wood was employed to a considerable extent in helping to discharge the routine duties of administration. Mr. H. R. Duhan, Personal Assistant to General Walker joined the office for a few weeks preliminary to retirement on pension

* Comprising the following parties :—
Secondary Triangulation (coast).
Tidal and Leveling
No. 1, Astronomical.
No. 2, ditto.
Darjeeling.
Guzerat.
Cutch.
Kashmir detachment.
Burma secondary.

302. The great work of the final reduction and publication of the various operations of the Great Trigonometrical Survey has been prosecuted with all the means available, and to this extent the progress made has been satisfactory in the aggregate; but the necessity for completing some nearly finished subjects, and for carrying on *several* works at the same time, besides unexpected diversions of computing power, served to diminish the progress both apparently and really.

303. The more important calculations of the year have been as follows:—

(*a.*)—Completion of the reduction of the triangulation in Southern India, known as the Southern Trigon: the simultaneous equations employed as usual involved only *single* chains of triangles, but as the series are almost without exception double, there thus remained a considerable number of figures to satisfy, and these have now all been adjusted; so that the principal triangulation of the Southern Trigon in respect to lengths, latitudes, longitudes, and azimuths, stands finally reduced. There remain the heights and the observed azimuths to be disposed of; also the secondary triangulation, of which there is a considerable amount.

(*b.*)—Computations for the volume of the astronomical latitudes have been steadily continued, and a large mass of results, the outcome of some forty thousand observations, are well advanced to the stage where they will admit of discussion and final disposal: the work was retarded for over three months from the necessity for lending a pair of computers to the two astronomical parties.

(*c.*)—Final reduction of the Eastern Sind Series has been completed.

(*d.*)—The Mergui Base-line has been reduced: the resulting value as brought down from Calcutta by triangulation and that by measurement agree exceedingly closely, there being a difference between them of only 0·13 inches per mile.

304. As regards the publications of the Operations of the Great Trigonometrical Survey, volumes VII and VIII, comprising the whole of the North-East

Quadrilateral, have been bound and distributed, as has also volume IX. The latter volume contains the results of the electro-telegraphic determinations of differences of longitude to end of 1880-81: the whole of the observations and reductions were made by Lieutenant-Colonel W. M. Campbell, R.E., and Major W. J. Heaviside, R.E.: the descriptive chapters and tabular arrangement are also due to Colonel Campbell. The volume was printed as usual in this office under the supervision of Mr. Hennessey, M.A., F.R.S., "who rendered material and valuable assistance" in its preparation.

305. Of the synoptical volumes, which furnish abstracts suitable for local wants of the final results both principal and secondary, five have been published or are in course of binding; viz., volumes XIV to XVIII, respectively, of the Budhon, Rangír, Amúa, and Karára, Gurwáni, Gora, Hurílaong, and Chendwár Meridional Series. Three other synoptical volumes are in hand.

A beginning has also been made with the printing of the details of the Southern Trigon.

But little progress has been made in publication of the valuable sheets of spirit levels for all India, because the drawing office was otherwise necessarily employed. Sheet 12 (3rd edition) of the North-West Provinces, including Aligarh, has, however, been prepared, and five others are in hand.

306. The compilation of the 6th edition of the map of Turkestan under General Walker's directions was completed and published in four sheets: it comprises all available geographical information to date from surveys by the officers and explorers of the department, as well as from other sources, as routes by Schindler, Floyer, Lessar, and Regel, Russian maps of various regions, &c., &c. A map of Afghanistan, enlarged from the Turkistan map, was also published.

307. The excellent and very considerable explorations by A— K— in Great Tibet and Mongolia were reduced, and a map prepared in three sheets, which, with an index, are given at the end of Appendix A.

In addition, an interesting map of Arabia and Persia in two sheets was prepared for the Resident in the Persian Gulf.

308. All the maps of the current year's work for the Guzerat and Cutch parties were examined and published; four charts of triangulation were prepared and printed; and for the Forest Survey Department, six maps were printed. Besides, a large amount of miscellaneous duties was disposed of, as may be seen in the appendix. The amount of money actually paid to this office for maps, &c., in the year, was Rs. 705.

309. The important duty of watching over the protection of the principal stations of the Great Trigonometrical Survey continued to be carried on with the necessary care. There are now 3,535 stations in 338 districts on the lists, regarding which correspondence has to be carried on with district officers, and bills audited. Of 317 district officers from whom annual reports were due, 78 (or one-fourth) failed to submit them.

310. Solar photographs for the Solar Physics Committee, South Kensington, have been taken, as directed by the Secretary of State for India, on every day of the year when the sun was visible; the negatives are sent to England by every mail, and are made use of also by the Astronomer Royal. In the year under report, invisibility reckoned by days occurred to the extent of 13 per cent., against 10 for 1881-82, and 15 for 1880-81, or an average of 13, while at Greenwich the average percentage for the same period was 50; the continuity of solar observation maintainable in the year is therefore about 318 to 183 between the two countries. The features photographed are not measured in this country, that duty being performed by the Astronomer Royal and the Solar Physics Committee, but daily inspection of the results leads to the general conclusion that solar activity was greater than due to the period that it has passed its maximum, while the mottling of the sun, after allowing for improved manipulation, appears more decided than usual: further observation may perhaps prove that this mottling has a periodicity hitherto not detected. The photo-heliograph in use is at present the old small instrument which at first gave only 4-inch results, but by means of the enlarging combination received during the year they are now of 8-inches, at the same time that the definition has not suffered.

311. The great photo-heliograph sent out by the Secretary of State for taking 12-inch pictures, arrived so far back as July 1882. Arrangements were

promptly entered into with the Superintendent of the Roorkee Workshops for the necessary rotating dome, and the building on which it should stand was put in hand without delay. The latter was finished in due course, but the dome still remained under construction, notwithstanding solicitations for expediting progress: in fact the monsoons of 1883 had to be encountered with the aid of a tent stretched over the walls in place of the dome,—a provision necessarily ineffectual, and which required the novel and further provision of opening a drain in the basement to discharge the downpour of rain. Eventually, by adopting primitive contrivances for rotating the dome and working the shutter, the structure was rendered workable about the end of September 1883. The instrument was thereafter set up and adjusted, but necessarily a great deal remains to be done before it will be fully established in good working order.

Actinometry.

312. In continuation of discussions by Professor G. G. Stokes, Professor Balfour Stewart, General Strachey and others, Mr. H. F. Blanford recommended that a European should be selected in England, trained, and sent out to take a series of actinometric observations at Leh (Kashmir): accordingly Serjeant B. Rowland, R.E., was sent out for the purpose by the Secretary of State, and landed at Bombay, 31st October 1882.

It was then too late in the season to proceed to Leh, and otherwise Mr. Blanford found it necessary to postpone the departure of the party: the serjeant was thus placed under Mr. Hennessey's orders. The delay was fortunate, as it was found that from want of sunshine in England his training was quite insufficient, and would have led to failure, the more so that he was not provided with instruments or material, and in fact the work to be undertaken being the first of its kind, there was no programme whatever of operations.

313. The duties which thus devolved on Mr. Hennessey were of too comprehensive a nature to be detailed here: they are, however, sufficiently explained in a suitable paper which has been printed and circulated.* It may, however, be briefly mentioned as to this scientific enterprise, that Serjeant Rowland and an assistant (entertained in India) were thoroughly instructed in their duties; the party was organized and fully equipped in every way, and above all, a suitable programme of operations was devised and developed into working order for adoption at Leh, where he observers are now at work. The party started from Dehra on 3rd October 1883.

314. Deep-sunk earth thermometers.—These thermometer bulbs, it will be remembered, are placed at the usual depths, below the surface, of 1·1; 3·2; 6·4; 12·8; and 25·6 feet. The series of readings are given in the appendix for 2 years and 7 months, but at present are insufficient for discussion and deduction of results. The general inference, so far as the facts go, probably indicates decrease of solar energy.†

315. Mr. H. R. Duhan retired on pension, 1st April 1883, having entered the Department in the corresponding field office, 22nd April 1845. In due course he was appointed Registrar of the office, and thereafter was nominated Personal Assistant to the Surveyor-General and Superintendent, Great Trigonometrical Survey. He served in the latter capacity for many years, successively under (the late) General Sir Andrew Waugh and General Walker, by whom his services have been frequently commended. Gifted with a tenacious memory, Mr. Duhan was expert in business, and possessing much courtesy of manner, he was held in general esteem.

Mr. Duhan rendered the last month of his service in the office of the Trigonometrical Branch, where such of his duties as now devolve on the Officiating Deputy Surveyor-General are efficiently co-operated in, besides his ordinary professional work, by Mr. C. Wood.

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* Actinometric observations at Leh. Note on preliminary operations, by J. B. N. Hennessy, M.A., F.R.S., &c. Professor Balfour Stewart in acknowledging this note (3rd January 1884) says, "Many thanks for your admirable note * * * which I have read with very great interest * * *, and I am sure it would add to the value of your scheme if you would undertake to examine and discuss the first year's work when completed."

† Mr Cole says of Mr. Wood—"I cannot too highly acknowledge his valuable assistance: his merits have often been brought to notice." The works of Mr. Peychers and Baboos Ganga Purshad and Cally Mohan Ghose in the Computing Branch are reported on very favourably. The services of Mr. Atkinson in the Drawing Branch and of Messrs, Clarke, Bond, Ollenbach, and Hughes are commended.

Summary of Out-turn of Work executed by the Triangulation and Spirit-leveling Parties of the Trigonometrical Branch, during the Survey year 1882-83.

Description of Details.	Secondary Triangulation Party, 12" theodolite.	Burma Party, 42" theodolite.	Spirit-leveling operations.	Total.
Triangulation.				
Number of secondary stations newly fixed ...	43	.....	12	55
,, ,, triangles completed ...	44	.....	24	68
Length of secondary series in miles	97	.....	.....	97
Area of secondary triangulation in square miles ...	474	.....	.....	474
Average triangular error in seconds	3·5	.....	.....	.....
Number of pillars and platforms constructed for secondary stations	37	.....	.....	37
Number of special beacons built	6	.....	.....	6
,, of principal or secondary stations protected and placed under official protection	37*	28	.....	65
Number of secondary stations, the elements of which have been computed	44	.....	12	56
Area embraced by triangulation to prominent points, exterior to main series, and in square miles ...	66	1,100	.....	1,166
Number of points fixed by intersection, but not visited	115	15	.....	130
Number of stations and points, the heights of which have been determined	70	15	34	119
Number of miles of rays cleared	36	.....	.....	36
,, of preliminary charts of triangulation ...	1	.....	.....	1
,, of hill tops cleared of forest and jungle ...	4	7	.....	11
Spirit-levelling.				
Number of miles leveled over	.....	.....	416†	416
,, permanent bench-mark stones embedded ...	.....	.....	42	42
,, trigonometrical stations connected with lines of levels	.....	.....	7	7
,, other permanent points fixed as bench-marks	.....	.....	418‡	418

* In addition, the six Beacons have been placed under official protection.
† Of this, 236 miles have been done by *double* leveling.
‡ These are chiefly Marine Survey Sockets and Bench Marks, Public Works Department and Irrigation Bench Marks, Hooghly River Survey Stations, Railway Bench Marks, and marks cut on Railway platforms.

Summary of Out-turn of the TOPOGRAPHICAL

Scale of survey.	Topographical Survey.	Instruments used.	Area triangulated in square miles.	Number of stations at which observations were taken.	Number of square miles to each point trigonometrically fixed.	Number of square miles to each height.	TRIANGULATION. 1ST CLASS TRIANGULATION, IN WHICH EACH ANGLE IS USUALLY OBSERVED ON FOUR ZEROS OR MORE. Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	2ND CLASS TRIANGULATION, IN WHICH EACH ANGLE IS USUALLY OBSERVED ON TWO ZEROS. Number of stations fixed.	Number of triangles.	Triangular error in seconds.	Error per mile in feet.	Number of heights.	3RD CLASS OR TERTIARY TRIANGULATION, IN WHICH TWO ANGLES ONLY OF EACH TRIANGLE ARE OBSERVED. Number of intersected points fixed.	Number of triangles.	Error per mile in feet.	Number of heights.	Number of extra heights determined by barometrical observations or otherwise.
1 inch=1 mile.	No. 1, Central India and Rajputana Survey.	12"	1,220	29	6	8·4	...	...	...	...	...	18	77	3·2	0·11	17	233	410	·63	158	55
	No. 2, Khandesh and Bombay Native States Survey.	10" and 6"	690	40	2·3	3·4	10	19	3·5	·09	10	26	86	14·5	2·9	26	221	353	2·4	135	90
	No. 5, Mirzapur Survey ...	.....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Mysore Survey	12"	2,500	51	5	5	...	...	...	...	...	43	55	5	0·2	43	454	750	0·9	454	2,095
1 inch=2 miles.	Baluchistan Survey ...	7"	...	23	...	...	20	28	17·9	...	22	1	1	20·6	...	1	83	122	5·6	32	231
2 inches=1 mile.	No. 6, North-Eastern Frontier Survey.	6"	258	33	2·4	6·8	...	...	...	...	...	23	55	42·4	1·43	16	56	76	1·3	25	...
	Guzerat	30" and 6"	901	55	2·6	4·1	...	...	...	...	...	49	93	11·8	0·21	42	239	434	1·06	193	797
	Cutch	7"	2,124	70	3·6	3·9	...	...	...	...	...	64	129	11·2	0·4	64	531	930	1·0	479	...
	Darjeeling	5"	69	12	2	6	...	...	...	...	...	...	...	...	...	...	9	19	2·8	10	2,268
	No. 5, Mirzapur Survey ...	7"	1,909	34	6·4	9·9	...	...	...	...	...	30	91	12·9	0·7	30	263	480	1·3	162	...
4 inches=1 mile.	Burma Survey	7"	157	12	11	11	...	...	...	...	...	30	15	4·1	0·2	10	4	6	0·2	4	4
12 inches=1 mile.	Mysore Survey	8"	40	15	0·4	0·4	...	...	...	...	...	...	...	...	...	...	100	...	...	...	...
1 inch=4 miles.	Sikkim	12"	...	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Nepal-Bengal boundary ...	6"	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Nepal	12" and 16"	3,000*	20	53	...	15	11	3·7	0·2	15	...	...	...	...	...	134	253	2·1	50	...
	Dardistan and Kishanganga.	7"	2,080	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Exclusive of Higher Himalayas.

Table showing cost in rupees per square mile of work done by various TOPOGRAPHICAL PARTIES.

Topographical Survey.	Scales of Survey. ½ inch=1 mile.	1 inch=1 mile.	2 inches=1 mile.	4 inches=1 mile.	Remarks.
Central India and Rajputana	6(a)	24	.....	.....	(a) Open, desert country.
Khandesh	.....	25	45	.....	
Mirzapur	.....	33	213(b)	.....	(b) First season. Rugged country.
Eastern Frontier	.....	.....	213(c)	.....	(c) Thick jungle.
Burma	.....	.....	.....	(d)	(d) The first season. No fair rate available.
Mysore	.....	18	.....	.....	
Baluchistan	20(e	.....	.....	.....	(e) A small party.
Kohat	.....	34	.....	.....	

PARTIES between the 1st October 1882 and 30th September 1883.

Scale of survey.	Topographical Survey.	Traverse. Instruments used.	Traverse. Number of stations at which the theodolite was set up.	Traverse. Linear miles, simple traversing.	Traverse. Linear miles, main circuits and Boundary survey.	Traverse. Average angular error per station in seconds.	Traverse. Average error per 1,000 links in links.	Traverse. Number of village trijunctions fixed.	Traverse. Number of plane-table points fixed.	Topography. Final topography completed during the season, in square miles.	Topography. Average number of plane-table fixings per square mile.	Topography. Number of linear miles of test line by which each man's work has been tested.	Names of districts, &c., through which the season's operations have been carried.	Area of triangulation in advance of topography in square miles.
1 inch = 1 mile.	No. 1, Central India and Rajputana Survey.	.....	...	...	...	...	...	...	...	845·5	6·9	.....	Marwar and Sirhoi	3,720
	No. 2, Khandesh and Bombay Native States Survey.	.....	...	...	...	...	...	...	...	546·0	7·0	18 and in situ.	Khandesh and outlying British villages in Aurangabad, Nizam's dominions.	1,271
	No. 5, Mirzapur Survey ...	.....	...	...	...	...	...	...	...	725·8	6·9	40·5	Partabgurh, Banswara, and Udepur.	906
	Mysore Survey	.....	...	...	...	...	...	...	...	4,644	11·2	646·3	Shimoga, Mysore, and Tumkur.	6,947
	Kohat District Survey ...	.....	...	...	...	...	...	...	...	1226·9	5·0	90·0	Kohat.	
1 inch = 2 miles.	No. 3, Central India and Rajputana Survey.	.....	...	...	...	...	...	...	...	5453·9	1·5	.....	Bickaneer, Joysulmeer, and Marwar.	
	Baluchistan Survey	.....	...	...	...	...	...	...	...	1344·3	.....	.....	alat and Soweston	4,806
	No. 6, North-Eastern Frontier Survey.	.....	...	875	...	...	...	...	...	296	2·2	86	South Sylhet and Khasia Hills.	2,894
2 inches = 1 mile.	Gazerat	6″	1,387	...	204·5	14·3	2·6	...	...	729·1	23·1	314·2	Lúnávádá, Bálásinor, Sunth, and Sanjeli States of the Rewa Kantha Political Agency, parts of Pardi and Bulsár, tálukas of the Surat Collectorate, Daman Territory.	
	Cutch	6″	832	740	...	17·8	1·3	...	...	1632·0	13·6	393·5	Cutch	2,124
	Darjeeling	.....	...	...	...	...	...	...	2,420	373	5·9	.....	Darjeeling.	
	No. 2, Khandesh and Bombay Native States Survey.	5″	517	257	...	3·1	0·7	154	42	990·7	29·5	120·2	Khandesh and outlying British villages in Aurangabad, Nizam's dominions.	
	No. 5, Mirzapur Survey ...	.....	...	...	...	...	...	...	...	215·0	41·0	32·1	Mirzapur	1,036
4 inches = 1 mile.	Gazerat	.....	...	...	...	...	...	...	...	602·6	61·4	337·6	Godra, Panch Mahals, Deng Forest and Kalvan, tálúka of the Nasik district.	332
	Burma Survey	5″	43·23	232·7	39·2	4·4	3·5	...	...	45·9	40·1	20·2	Tharrawaddy (British Burma).	180
	Nepal-Bengal boundary ...	6″	763	19	271	3	0·75	162	...	120	.....	.....	Bhágalpur, Durbhunga, Mozufferpore, and Chumparan.	
6 inches = 1 mile.	No. 6, North-Eastern Frontier Survey.	.....	...	...	...	...	...	...	...	7·0	75·0	.....	Shillong Sanitarium.	
12 inches = 1 mile.	Mysore Survey	.....	190	...	29·2	...	...	...	...	.....	.....	.....	Town and cantonment of Bangalore.	
16 inches = 1 mile.	No. 5, Mirzapur Survey ...	5,″ 6,″ & 8″	710	4·1	12·0	...	0·04	...	61	.....	.....	.....	Dadhi Pargana.	
1 inch = 4 miles.	Sikkim	.....	...	...	...	...	...	...	...	.....	.....	.....	Sikkim	
	Nepal	.....	...	...	...	...	...	...	52	*	.....	.....	Chumparan and Nepal ...	
	Dardistan and Kishangunga...	.....	...	...	...	...	...	...	...	2,000	.....	.....	Dardistan and Kishangunga.	

* The area sketched (Gunduk basin) is not stated, as it is not as yet final.

Summary of the Out-turn of the Field Work of the REVENUE BRANCH

Designation of Survey Party.	Scale of Survey.	Where Employed. Province.	Where Employed. District.	Number of villages.	Area competed. Topography and detail.	Area competed. Traverse. In advance.	Area competed. Triangulation. In advance.
					Cadastral Surveys. Sq. miles.	Sq. miles.	Sq. miles.
No. 4 party ...	16 inches = 1 mile ...	North-West Provinces ...	Ballia	226	224	.....	.....
			Benares	552	551	356	.....
„ 5 „ ...	Ditto ...	Ditto	Mirzapur	522	624	.....	.....
			Tarai	23	23	.....	.....
			Gorakhpur	.....	.....	264	.....
„ 2 „ ...	Ditto ...	British Burma	Hanthawaddy	72	118	.....	.....
			Pegu	312	480	360	.....
„ 7 „ ...	Ditto ...	Ditto	Tharrawaddy	69	209	.....	.....
			Prome	334	610	54	.....
„ 8 „ ...	Ditto ...	Ditto	Bassein	191	441	.....	.....
			Henzada	75	177	465	.....
		Total of Cadastral Surveys ...		2,751	3,237	1,539	.....
					Riverain, Forest and Mauzawar Surveys.		
No. 3 party ...	4 inches = 1 mile ...	North-West Provinces ...	Bulandshahr, Aligarh, Etah, (Ganges river survey), Aligarh and Bulandshahr (Jumna river survey),	.....	205(2)	.....	.....
„ 4 „ ...	Ditto ...	Bengal	Shahabad (Ganges river survey) ...	288	203	.....	.....
			Saran (Gogra river survey) ...	138	125	.....	.....
„ 10 „ ...	Ditto ...	Bombay	Thana	.....	663	490	1,015
„ 1 „ ...	2 inches = 1 mile ...	Punjab	Hissar	297	1,661	1,869	.....
		Total of Riverain, Forest, and Mauzawar Surveys ...		.....	2,936	1,539	1,015
					Topographical Surveys.		
No. 6 party ...	16 inches = 1 mile / 6 Ditto ...	Bengal	Hooghly, Midnapore, and 24-Pergunnahs.	.....	29	.....	.....
			Ditto ditto	.....	109	.....	.....
„ 3 „ ...	2 Ditto ...	North-West Provinces ...	Aligarh	.....	1,224(4)	.....	.....
			Bulandshahr	.....	528	869	.....
			Etah	.....	27		
„ 5 „ ...	Ditto ...	Ditto	Mirzapur	.....	27	.....	.....
„ 10 „ ...	Ditto ...	Bombay	Thana (Jawar State)	.....	14	.....	.....
„ 11 „ ...	Ditto ...	Ditto	Satara, Ratnaghari, Sholapur, &c.	.....	1,800	1,728	576
		Total of Topographical Surveys ...		.....	3,758	2,597	576
		Grand Total ...		.....	10,003	5,655	1,591

Abstract according to Jurisdictions.

Province.	Scale of Survey.	Area surveyed in square miles	Cost.	Average rate per square mile	Remarks.
			Rs.	Rs. A. P.	
North-West Provinces	16 inches = 1 mile ...	1,232	1,53,200	150 5 1	Cadastral.
	4 do. = 1 do. ...	506	16,446	34 2 2	
Punjab	2 do. = 1 do. ...	1,806	50,065	27 11 9	
	2 do. = 1 do. ...	1,651	51,484	32 0 3	
Bengal	16 do. = 1 do. ...	29	31,554	1,094 12 2	A very close survey of intricate Bengal village sites.
	6 do. = 1 do. ...	109	22,033	210 7 0	
	4 do. = 1 do. ...	325	25,096	84 14 4	
British Burma	16 do. = 1 do. ...	2,035	5,45,206	266 14 11	Cadastral.
Bombay	4 do. = 1 do. ...	663	52,942	79 12 2	
	2 do. = 1 do. ...	1,514	51,304	33 8 11	
	Total ...	10,003	20,39,275	...	

Surveyor-General's Office,
Calcutta, the 1st October 1883.

PARTIES between 1st October 1882 and 30th September 1883.

Designation of Survey Party.	Cost.	Rate. Per acre.	Rate. Per field.	Number of fields.	Average size of fields.	Remarks.
	Rs. a. p.	Rs. a. p.	Rs. a. p.		Acres.	
No. 4 party ...	30,532 3 1	0 3 5	0 3 0	163,616	0·87	
	56,991 6 0(a)	0 3 9	0 2 11	315,642	0·77	(a) Exclusive of Rs. 3,536-4-2 expended on theodolite station marks.
,, 5 ,, ...	90,527 3 3(b)	0 3 10	0 6 2	248,618	1·00	(b) Exclusive of Rs. 4,690 expended on station marks, and Rs. 6,288-14-5 expended in completing Nagri khasras and jumnabandi slips.
	3,539 0 0	0 4 2	0 6 2	9,988	1·47	(c) Exclusive of Rs. 6,502-2-8 expended on demarcation.
,, 2 ,, ...	3,35,104 3 7(c)	0 7 9	0 4 7	650,560	0·62(f)	(d) Exclusive of Rs. 2,055-0-3 ditto ditto.
,, 7 ,, ...	2,79,107 5 11(d)	0 5 5	0 3 1	131,028	0·22(f)	(e) Exclusive of Rs. 1,467-3-5 ditto ditto.
				782,150	0·32(f)	(f) The average size of fields is on the cultivated portion only.
,, 8 ,, ...	2,78,903 14 7(e)	0 7 3	0 5 5	538,194	0·33(f)	(g) Inclusive of 129 square miles of overlap survey on districts Budaun, Gurgaon, and Delhi. (h) Exclusive of Rs. 11,342-10-4, cost of marks fixed for settlement survey. (i) Inclusive of Aligarh City area = 4·05 square miles surveyed on the 6" scale.
	7,31,605 4 5					
		Per square mile.				
		Rs. a. p.				
No. 3 party ...	10,445 15 3	34 2 2				
,, 6 ,,	11,146 13 8	54 14 4				
	6,819 9 6					
,, 10 ,, ...	52,911 15 10	79 13 7				
,, 1 ,, ...	61,483 14 8(h)	37 0 3				
	1,42,878 4 11					
		Per acre.				
No. 9 party	31,561 2 3	1 11 6				
	22,553 6 7	0 5 3				
		Per square mile.				
,, 3 ,, ...	49,007 7 2	27 9 7				
,, 5 ,, ...	988 0 0	26 9 6				
,, 10 ,, ...	2646 0 0	16 2 3				
,, 11 ,, ...	51,157 9 0	29 6 9				
	3,56,601 12 6					
	10,30,925 5 10					

District completed since last Report.

District.	Area in square miles.	Cost, inclusive of all expenditure.	Final rate per square mile.	Nature of survey; by whom and when surveyed.	Remarks.
		Rs.	Rs. a. p.		
Bulandshahr	1,897	61,530	32 7 0	Surveyed topographically on the scale of 2 inches to the mile by Mr. E. T. S. Johnson; commenced 1881-82, finished 1882-83. A line of villages in area 201 square miles along the Ganges and Jumna rivers has been surveyed on the scale of 4 inches to a mile.	Excluding the 4" survey, the cost rate of the 2" survey is Rs. 23-16-10 per square mile.

J. SCONCE, *Colonel,*
Deputy Surveyor-General.

APPENDIX.

EXTRACTS

FROM

THE NARRATIVE REPORTS OF THE EXECUTIVE OFFICERS

IN CHARGE OF

THE SURVEY PARTIES AND OPERATIONS.

Extract from the Narrative Report of J. McGILL, Esq., *Deputy Superintendent, Survey of India, in charge Secondary Triangulation Party, season* 1882-83.

FROM Pooree the field season's work commenced; seven days were spent in endeavouring to find the pillars of Gobarsai, Batkiapukri, Bálikhand, and other stations which were in the vicinity of Pooree; but after much labor and loss of time, in digging into sand hills at the sites of the stations, and making careful enquiries as to the exact positions of the station pillars, I had to give up all hope of succeeding in tracing them. In some cases, the sand hills, on which the stations were represented to have been built, had been completely swept away by the wind; in others they had been raised 15 to 20 feet higher by accumulation of sand. The station of Gobarsai, which is on a sand hill near the sea-shore south-east of Pooree, was about 30 feet high when the first station pillar was built on it, and this ridge has now been raised to a height of 40 feet by gradual deposit of sand. I dug down to a depth of 15 feet at the spot indicated as the site of the old station, and found no signs of a pillar.

At last I decided to commence the new triangulation from Pooree, building station pillars on the approximate sites of old stations, and continuing the series southward along the sea-coast, until the existing hiatus in the coast triangulation between Pooree and Bodágiri was filled in.

The men of the native establishment suffered very much from fever, there being at one time as many as twenty in hospital; but as the paddy fields began to be cut, and the water to dry up, the country became healthier, and the work progressed more rapidly.

To save time and expense in building towers for observing from in the low jungly country, I had a temporary large trestle, 8 feet high, made at Pooree, on which the usual instrument trestle could be placed for observation, thus enabling me to observe from a height of about 14 feet from the ground; the signal in such case being also raised 12 feet and more by erecting scaffoldings of bamboos over the station pillars observed to.

The series is based on the side Chandíkho H. S. to Tárá Tarni H. S. of the East Coast Series, and the computations are in terms of this side.

The station pillars of Harchandi and Bondálo of the Minor Coast Series being found, this side is taken as one of the sides of comparison, and the stations of Bodágiri, and Ichápur of the East Coast Minor Series to the south gives another verificatory side.

The work in the vicinity of the Chilka lake was very arduous and trying, both on account of the low malarious nature of the ground, as also the trouble of having to adopt water-carriage by canoes in crossing the different arms of the lake.

The eastern flank of the series runs along the sand ridge on the shores of the Bay of Bengal, and the western flank about 5 miles inland; the stations in most cases being on islands, or on the slip of land lying between the Chilka lake and the Harchandi creek.

Along the sea-coast, at intervals of about nine miles, beacons 15 feet high have been erected on suitable spots as objects for intersection by marine surveyors; except in cases where conspicuous temples or other objects afforded good land-marks for the same purpose; all these conspicuous objects have been intersected and their positions accurately determined.

The station pillars and beacons which were erected (47 in number) were all made over to the native officials for safe custody. The station pillars were built circular, of pucca masonry, with mark stones (with circle and dot) at foundation level and top, usually 2 feet high; the upper mark stones being in every case protected by a rectangular pillar 3½ feet high, also of pucca masonry. The beacons were 15 feet high, 4 feet foundation, 4 feet square at base gradually tapering to a point like an obelisk. A mark stone with the letters G. T. S. engraved on it has been let into the masonry of each beacon, 10 feet above ground level.

Small game of all kinds is plentiful. Antelope are seen in herds near the sea-shore, and wild pig in the jungles. Duck of all kinds and geese are seen in thousands on the Chilka and its numerous inlet feeders, and snipe in jheels. After the grain has been cut in February, grain-quail and partridge are seen. Fish of a superior kind, and crabs and prawns can be had in the Chilka, and are largely exported. The country is in a very primitive state, and possesses no roads; and being covered with deep sand, and intersected by numerous creeks or jheels, it is difficult to travel over.

The Chilka is an immense stretch of salt water, covering an area of about 350 square miles. It is fed by the freshets of the Mahánadi river, and by numerous small streams descending from the hills near Rambha and Basanpur, a portion of the eastern ghâts. It has only one outlet into the sea, by a small breach in the sand ridge, one and half miles east of Arakudo village, called Naia Mohan, near which a beacon 15 feet high has been built. The southern shore of the Chilka is being gradually silted up, and in many parts, is not over 2 feet in depth. Numerous islands have been already formed, some of which cover an area of 8 square miles, in which are villages with extensive fields of coarse rice; a large quantity of salt is made in some of these islands.

Pooree is a well-known place of pilgrimage, and held in veneration by all Hindus as the residence of Jagannáth, an incarnation of Krishna. Thousands of pilgrims from all parts of India visit Pooree to worship at Jagannáthji's temple. Within the limits of Pooree town, caste is not observed; all may eat together, the Brahmins with the meanest Sudras. Krishnaji orders all caste prejudices to end at the gates of Pooree.

The country from the western border of the Chilka to latitude 19° 3′, longitude 84° 38′ is hilly, the hills in parts bordering the shores of the sea. It appertains to the Ganjam district of the Madras Presidency. The people are Telingas or Coringies, and speak the Telegu language; and they are a bolder and more independent race than the Ooriyas of the Pooree district. The cultivation is also more varied. Bajra and ragee are grown, and in some places cotton and a thin kind of sugarcane, from which the well-known Ganjam sugar is made; and the hills being very woody, large quantities of timber for sleepers, and bamboos for building are exported *viâ* Gopálpur to Calcutta; also rice and sugar. At Aska there are sugar mills and distilleries of rum and brandy. A canal has been cut connecting the Chilka lake with the port of Ganjam, by which communication is kept up with the country bordering the waters of the lake, and a fine high road connects the towns of Rambha, Ganjam, Chatrapur, Gopálpur, Berhampore, and Ichápur with other towns along the coast, and with Cuttack; and a branch road has been made to Aska. The country is well inhabited, and some of the villages are large, with thriving communities. It is however generally unhealthy, and fevers are very prevalent, more especially in the vicinity of Ganjam and the Chilka. The hills are of granite, or basalt and laterite, and are covered with low jungle, and are well stocked with game; tigers and bears, and other large animals being frequently met with, and even wild buffalo. They are very rocky in places, composed of boulders of rock thrown in chaotic confusion, forming caves and chasms, and in others standing up like temples 20 to 40 feet in height. The people are almost exclusively Hindus with a very small proportion of Mahomedans. The only river of any size which flows through this portion of Ganjam is the Rushikulja, which rises in the Goomsur hills, and running a course of about 80 miles, falls into the sea at Ganjam. It has a broad sandy bed with little water in it. The inhabitants depend on wells and tanks for water almost entirely.

Ganjam, the capital of the district to which it gives its name, is also a sea-port, but not of much account, owing to its extreme unhealthiness.

Berhampore, a fine large town of some 23,000 inhabitants, situated at the foot of some low rocky hills, is considered one of the healthiest localities of Ganjam.

Gopalpur is a sea-port of Ganjam, which is daily rising in importance; it has at present three European firms doing business as shippers of grain, sugar, wood, &c. The port is closed during the monsoons owing to the heavy surf which at all times is high, requiring the use of Masula boats to put out to the ships in the roads.

Sonapur is a small sea-port town at the mouth of a small mountain torrent; it has a population of about 2,000, and its exports are chiefly rice and salt. It is almost surrounded by a salt marsh, and is only about 4 feet above sea-level.

Extract from the Narrative Report, dated 27th September 1883, *of* Major J. R. McCulleagh, R.E., *Deputy Superintendent, Survey of India, in charge Burma Party.*

I received charge of the party by letter from Lieutenant-Colonel M. W. Campbell, R.E., during November 1882, and the establishment, consisting of Moung Shoay Gyoke, sub-surveyor, and six men, arrived in Rangoon on the 22nd of the month.

The latter part of November and beginning of December was taken up in making preparations for taking the field, recruiting some more men, &c., and on the 18th December Moung Shoay Gyoke left for Prome.

The route sketched out for the sub-surveyor to follow was from Prome to Thayetmyo, then across to Toungoo, and round by Shoaygeen and Pegu back to Rangoon, closing the stations in these different districts on his way, observing at the more northern ones to points beyond the frontier, and finally closing the stations south of Rangoon last of all.

This programme was carried out as far as practicable, but unfortunately the sub-surveyor found it impossible to cross over from Thayetmyo to Toungoo without the aid of an elephant to carry the baggage, and an elephant he was unable to obtain notwithstanding that he had been kept waiting some days, and he consequently had to retrace his steps, come back to Rangoon, and then proceed by water to Toungoo. From Toungoo the programme was taken up again and carried out as given in the previous paragraph.

The work of the season came to a close on the 7th June.

The results of the season's work are as follow:—Moung Shoay Gyoke visited 34, and transferred, closed, and protected 28 stations; he also observed at 4 stations with a view to cutting in peaks and any conspicuous objects beyond the British frontier. These observations have not as yet been worked out, for the sub-surveyor has been absent on other duty, and I have not had time myself nor have I been able to spare the services of any of the assistants of my cadastral party to go into the matter.

Extract from the Narrative Report of Major C. Strahan, R.E., *Deputy Superintendent, Survey of India, in charge Central India and Rajputana Topographical Survey,—season* 1882-83.

Country plane-tabled. Sirohee and Marwar.

On the one-inch scale, 846 square miles were surveyed, of which 523 square miles lay in the state of Sirohee, whilst the remainder was in Marwar (Jodhpore). It comprised the whole of standard sheet 99, western half of standard sheet 96, and a few square miles in standard sheet 100. Nearly in the centre of standard sheet 99 is the town

of Sirohee, the residence of a Rajah, but it is only a small unimportant town. It is situated to the west and at the foot of a rugged range of jungle-covered hills known as the Sarnau. Commencing not far south of the cantonment of Erinpura, the range takes a general direction nearly south-west, the ground to the east rising very much more rapidly than that to the west, so that at Sirohee, a distance of 23 miles, the difference of level is about 450 feet. The hills here are very narrow, consisting in fact of only a single chain, whereas up to this point the range consists of a confused mass of hills some 4 or 5 miles wide. Over this neck is carried a very good cart-road, which connects Sirohee with Pindwara station of the Rajputana-Malwa Railway; it is not metalled, but is in very fair order. The ascent from the west commences a little more than a mile from the town of Sirohee, 1,000 feet above sea level, and continues at a considerable slope for about another mile, and after that at a very slight gradient for another 1¾ miles, when the watershed is reached. The ascent in the 1 mile is about 350 feet, another 100 feet taking you up to the watershed. The descent to the east is so gradual that it is not noticeable to the eye, the railway-station of Pindwara, 1,210 feet above sea level, being only 230 feet below the watershed, and the slope being quite gradual throughout the whole 10 miles. The total distance from Sirohee to Pindwara railway-station is nearly 14 miles. To the south of this pass the hills again widen out, and also increase in height, the highest point of all being Makrora, H. S. 2,773 feet above sea level and 2½ miles south-east of the village of that name, which is 1,053 feet above the sea. Amongst these hills, sambhur, bears and tigers may be found; bears being rather plentiful. To the west of this range, and passing within a mile of the town of Sirohee, runs the road from Ajmere to Deesa. So far as the survey has gone it is metalled, but I am informed that a little beyond, it is what is called a fair-weather road only. Again to the west, the country is generally flat, isolated rugged hills or ridges rising occasionally; the soil becomes more and more sandy, and water more scarce as the desert is approached, but no portion of the State of Sirohee can be said to be desert; indeed, I think if it were not for the lawless state of the country, and the extreme poverty of the Durbar, it would be in many parts very fertile, but a considerable outlay for clearing jungle and sinking wells, besides an increase to the number of inhabitants, would be required in the first instance. The western portions of standard sheets 96 and 99 are situated in Marwar, which is nearly all flat country, but with isolated and remarkably rocky hills occurring at intervals. The Echrano range in particular is worthy of notice for the immense size and fantastic shapes of the granite or gneiss boulders of which it is mainly formed. More than one of the peaks are inaccessible; in one case the summit of a rocky hill is surmounted by a single rock, standing up like a tower, except that it is somewhat larger at the top than at the bottom, and is by measurement upwards of 400 feet in height and cannot well be much more than 40 feet in diameter anywhere.

* * *

Bickaneer and Joysulmere.

As the distances to be covered were considerable, it was necessary to mount the men and instruments on camels, carrying water on an extra camel if required. I had attempted to sling the stand and umbrella, one on each side of a camel and so save one man, but it was found impossible to prevent them from swinging and frightening the camel unless they were so elaborately fastened as to make it very inconvenient unfastening and fastening them up again, so we had to take one man for each article and let him carry it on the saddle in front of him. A plane-tabling party going out to work was generally mounted on four camels; on the first, leading the way, was the surveyor, usually without an attendant, on the second would be a guide with a klassie seated behind him, with the plane-table slung on his back, and on the third would be two klassies, one carrying the umbrella and the other the stand resting on the saddle in front of them, whilst the fourth would carry a pair of water-skins and a villager. As soon as the surveyor and klassies had become thoroughly used to camel-riding considerable distances could be traversed, but in the country under survey this year, for the most part thickly covered, as it was, with sand hills, it was rather slow and monotonous work. Camels were very quickly knocked up by the constant labour of ascending and descending the sand hills, and if it had not been for the willingness of the inhabitants to supply camels every day, we should never have got through so much work. Three days a week was as much as any one camel could stand, even if he had only to carry the surveyor without an attendant. Camels of a certain stamp (not a very high one) are to be found in numbers, but really first-class riding camels are not often met with, and are much prized by their owners. The ordinary animal is both slow and rough, and has by no means the endurance that I had expected to find. The general rate for a village camel was three annas a day, but the Durbar had issued orders that one riding camel should be given every day to each camp, free of cost, and this was made use of by the surveyor to ride in turn with his own camel. Immediately after leaving Nokh, I found myself in a regular sea of sand hills, and until I reached standard sheet 121, they formed an unbroken mass; they varied from what may be called ripples of 15 to 20 feet in height, up to huge waves of some 180 feet from trough to crest. They are all more or less parallel, having being formed by the prevailing wind which is from the south-west. The north-east face is always as steep as the loose sand will admit of, whilst the south-western is gently sloping, and formed in long spurs. There is a considerable amount of coarse grass growing in tufts all over the sand hills, together with small shrubs, and in the valleys, stunted trees are by no means uncommon. In the rains I am told it is a very green country, and the pasturage is capital. A great deal of bajra is grown during the monsoon in the sand between the sand hills, so much so that I met several strings of camels about Phalodi and Bap exporting bajra from the more northern parts. The water-

supply is of course the great difficulty; wells are met with not only at the villages but also in other places, but the very best water they yield is brackish, and as a rule is too salt for drinking purposes, whilst in many cases it is so bad as to be quite poisonous and unfit even for cattle. All through sheets 124, 125, 126, and 131, the only drinking water is from "tankas" or from "tobas." The former are circular pits puddled with clay, and covered in with wattle and daub domes, in the top of which are small trap doors which are kept locked; in these the villagers store rain water; the latter are small and somewhat deep ponds dug in the valleys where the soil is clayey, and are filled by the rain; these latter of course do not last long, and then the inhabitants are entirely dependent on their tankas, whilst their cattle migrate to places where the well water is fit for their use.

The Bisnuis whom I have already mentioned are a sect worth noticing, as they are quite distinct from the other inhabitants, and I believe are only found in Bickaneer, Jeysulmere, and Jodhpore. The following information I obtained from one of their priests or *guru* in Jeysulmere:—The name Bisnui is derived from the words, *bis*, 20, and *nau*, 9; their commandments being 29 in number. They worship one god, Jambuji, to whom there is a shrine at Mokam in Bickaneer, about 25 miles south-east of Desnok; here their chief priest resides. So far as I could make out, their existence dates from the time of Pailad, some 440 years ago by the Hindu reckoning. They have no subordinate castes amongst themselves; all are equal. They may not intermarry with any other castes, nor will they receive a man as a convert, but a child whose parents were of another religion may be adopted and brought up as a Bisnui. The children are betrothed at a very early age, when the father of the boy presents a cocoanut and a rupee to the father of the girl. When the girl is about 12 years of age, her father sends a yellow thread to the father of the boy, who ties it in his *puggree*, and then goes to the bride's father with the bridegroom and the guests. During the day of the marriage, a feast is provided for all the guests, and in the evening, all being assembled, the priest joins the right hands of the two, and the marriage is consummated. A man as a rule has only one wife, but if she bears no children, he may marry again. A widow may marry her brother-in-law, and there is no absolute rule against her marrying any one, but she is expected not to marry a man of the same village as that of her late husband. A Bisnui may under no circumstance take life, not even of a snake or other noxious animal; the consequence is that animals and birds within their village boundaries are curiously tame; the chikára wander about close to the huts, and will hardly run away from you; even the rats are less shy. They will not only kill no living creature themselves, but will not allow others to do so on their lands, and, if you bring the carcass of a chikára or any game into one of their villages, they will come to your tent and make a great fuss until you pacify them by a present of Rs. 7 or Rs. 7-8; of this they invest Rs. 5 in a bull calf which is marked and turned loose, and the remainder is for grain for the birds. They call chikára, dádá (father's father), and it is rather alarming if on your arrival at one of their villages they come demanding redress for their grandfather, whom they assert you have shot; the term dádá is applied, I believe, to all large animals as well as to antelopes, and náná (mother's father) to rats and all small animals. The dead are buried in the village, below the cattle yards, at a depth of about three feet; no mark of any sort is placed over the grave. The leading points of their 29 commandments are as follow:—

Drinking water to be strained and logs of wood to be shaken for fear of accidentally destroying insects; no animal to be killed, maimed, galt or cruelly treated by a Bisnui; and no other person to be allowed to do so within the village boundaries. No green or living trees to be cut or mutilated (this does not apply to grass or brushwood). Opium, tobacco, bhang, and wine are all strictly prohibited, as also is the use of indigo as a dye. A tenth of all the produce of their fields is to be given in charity. The first of each month (the new moon) is a fast day. Other commandments refer to their treatment of women. Their prayers enjoin patience, or forbid stealing, slandering, lying, using abusive language, &c. One would think from the general tenor of these commandments that the Bisnuis were a very quiet and peace-loving people, but our experience by no means proved that; very little is sufficient to arouse their anger, when they will come clamouring to the camp demanding redress, armed with clubs, which I fancy they would not scruple to make use of if not appeased. Still I must say they are civil enough if their little prejudices are respected, and it is generally one's own fault if you arouse their anger when you once know what to avoid when within their lands.

Extract from the Narrative Report of MAJOR T. T. CARTER, R.E., *Deputy Superintendent, Survey of India, in charge Bhopal and Malwa Topographical Survey,—season* 1882-83.

Remarks on country triangulated—Standard Sheet No. 54. Bhopal and Malwa survey.

THE small portion of country triangulated is for the most part easy ground, open, and undulating; the belt of country, three miles in width, forming the western limit of work, was rugged.

Sheet No. 54, Bhopal and Malwa Survey, is traversed by a marked range of hills running through the middle of the sheet, extending from Semlai H. S., Long. 73° 59′ eastwards through Deokotta H. S., Long. 74° 12′,

a station of the Singhi series, Saraugaon H. S., Long. 74° 29′, to the eastern margin. The country to the south of this range consists of small plateaux intersected by a few streams and covered with a thick forest of teak wood. To the north of the range the country forming the north-west corner of sheet 54 consists of very intricate ground with low features, the tops bare, but the valleys, which are narrow, are well-cultivated. The country to the north and east of the range is a flat plateau, richly cultivated and covered with numerous large villages. The principal rivers passing through this sheet are, first, the Mahi, which flows through the western corner, cutting off an area of some 25 square miles and dividing the Banswara and Dungarpur Native States. The Anás and its tributary, the Mangduri, cross the sheet from south-east to north-west and fall into the Mahi. The country on both banks of the Anás river is very intricate, the stream passing through a mass of small hills rising abruptly some 500 feet above the bed of the river; it is deserted for many miles along the stream, and the hills are thickly covered with forest. The above-mentioned rivers are only fordable at certain places all the year round, and even then guides are necessary to enable the traveller to pick his way among the large boulders strewing the waterway. There are no roads of importance. Traffic is carried on principally on pack-bullocks or ponies; though a few carts of very inferior kind are used to carry grain from the field to the villages. The only carriage practicable for the surveyors was camel carriage; fortunately there are fair roads passable for camels between the villages of Barodia, Kulinjra, Selgari, Chaundwara, Kotra, Semlai, Ghoge, and Garhi which are large ones fairly scattered over the area to be surveyed.

Remarks on country plane-tabled Sheet No. 36.

Sheet No. 36 comprises a large portion of the Pimpalner taluka which is the most mountainous of the Khandesh sub-divisions. At the north-west corner of the sheet the Sahyádri hills rise abruptly from the valley of the Tapti, some 1,400 feet, the general height of the edge of the ghát being 2,300 feet above the sea. The rivers Khan and Buray take their source on these highlands, and tending eastwards, divide the sheet into two marked valleys, the country on either side of them rising rather abruptly and forming two plateaux, these latter gradually sloping away as they tend eastwards from a level of 2,300 to 1,450 feet above the sea. The slopes of the Sahyádri hills are densely covered with forest, and now form the large reserve forest of Amli, of an area of 53·4 square miles or some 34,000 acres. The smaller reserve forest of Buray, 24·7 square miles, or 16,000 acres, and Pán, 26·7 square miles, about 17,300 acres, taking their names from the above-mentioned rivers, also enter into this sheet. The highlands on which these rivers rise are inhabited entirely by Konkanis, a tribe who live much as the Bhils and only cultivate such coarse grain as Nágli, Savá, Bharti, and Khúrsana. The Khan and Buray rivers are largely used for irrigation; masonry dams being thrown across them at several places from which small irrigation canals are taken out; the valleys are therefore well-cultivated, but the slopes and tops of the plateaux are mostly bare and covered with prickly cactus. To the north of this sheet lies a portion of Nandurbár taluka consisting of extremely rugged and intricate ground and a notoriously unhealthy tract. The sheet as a whole may be considered a difficult piece of work, for the most part hilly, wooded, and by no means healthy.

Sheet No. 39.

Sheet No. 39 comprises 119 square miles of the Dhulia and 105 square miles of the Chálisgaon talukas of Khandesh, and an overlap of one mile into the neighbouring district of Násik. Portions of the Bori and Girna rivers pass through this sheet. The country to the east, on the borders of Násik and Khandesh is hilly and wooded and much cut up with ravines. The main road from Chálisgaon, a station on the Great Indian Peninsula Railway, to Dhulia, passes through the eastern portion of this sheet. The country is for the most part sterile, the soil being very poor.

Sheet No. 40.

Sheet No. 40 is chiefly comprised of 125 square miles of the Chálisgaon taluka, Khandesh, and an overlap of one mile into the Násik district to the west, and along the banks of the Manyád river where it forms the boundary between Khandesh and Násik. The country is raviny and wooded, while to the south the Sátmála hills rise abruptly some 1,500 feet above the surrounding country, the faces of the hills forming natural scarps in most cases quite impossible to climb. This portion of the Sátmála hills and the belt of country at the foot of the same for a distance of from one to three miles, form part of the Satna reserve forest. The portion of the forest lying at the foot of the hills is well-stocked with young Anjani trees (Hardwickia binata), while the portion above the ghâts contains Salai (Boswellia thurifera), Sagwan (Tectona grandis), Tembhurni (Diospyros montana), Dáwda (Conocarpur latifolia), besides Bel, Bábhul, Bar, Hivar, Khair, and Pallas.

A portion of the Great Indian Peninsula Railway between mile-stones 191 to 203 from Bombay, passes through this sheet.

Sheets Nos. 41 and 42 and portion of sheet No. 24.

These sheets have been surveyed on the scale of one inch to the mile for reproduction. They are extraneous to the general survey of Khandesh, lying on the uplands of the Sátmála hills, and would not have fallen into the work of this party, but that in His Highness the Nizam's territory immediately above the ghâts, there are certain British villages, some belonging to Khandesh and some to Násik, scattered about.

Rising abruptly from the plains of Khandesh, Chálisgaon taluka, to the north and Násik to the west, some 1,600 feet, the watershed of the Sátmála hills is reached; the country then slopes gradually southwards. Near the top of the ghâts it is well wooded, but it is soon

brought into cultivation, and assumes the appearance of a large, well-cultivated plateau, some 1,900 feet above sea-level, of slighty undulating open country, studded with numerous villages.

Towns, &c.—Sheet No. 36.

Eighteen miles of the main road from Nandgaon to Aurungabad pass through sheets Nos. 41 and 42. The country was easy of survey, except towards the north-west and east where it is hilly and wooded. Nizámpur, Lat. 21° 6' Long. 74° 22', population 943, the head-quarters of a peta or petty division of the Pimpalner taluka, the first great town on the road from Surat to Agra. Fragments of Hanadpant temples erected at the beginning of the sixteenth century show that before Musalman times it was a place of consequence; it is now nothing more than a fair-sized village, with a school (well attended), post-office, and Mahalkari's court.

Sheet No. 39.

Borkund, a large village, Lat. 20° 43' Long. 74° 55', population 1,873, with a school and police-station on the Bori river.

Sirur, Lat. 20° 44' Long. 74° 36', population 1,884, with a post-office on the Bori river.

Mehunbára, a large village on the Girna river, Lat. 20° 38' Long. 74° 50', population 1,597, and a post-office. Saigaon, Lat. 20° 38' Long. 74° 50', population 1,340, at the junction of the Manyar river with the Girna. It is proposed to build a large dam across the river to store the whole of the drainage into the Manyád and supplement the water-supply of the Girna for irrigation purposes.

Sheet No. 40.

In sheet No. 40 there is nothing but the ordinary villages.

Sheet No. 24.—Kanad.

Sheet No. 24, Kanad, in the Nizam's territory. About 30 years ago a cantonment was constructed for a regiment of the Hyderabad contingent, who were placed there to keep in order the Bhils, then infesting the neighbouring Sátmála hills. Nothing is now left of the cantonment except the shell of one house. At present it is the head-quarters of the Kanad taluka. Aurungabad, district of the Nizam's country lies in Lat. 20° 15' Long. 75° 11', and has a population of 1,865 souls. It has a post-office under the British postal authorities.

Sheet No. 41.—Wakla, Shiur.

Wakla, Lat. 20° 12' Long. 74° 55', population 1,521, and Shiur, Lat. 20° 4' Long. 74° 52', population 4,053, are large villages. The latter has a school.

Sheet No. 42.—Chikhalthan, Hatnur, Chapanor.

Chikhalthan Lat. 20° 11' Long. 75° 14', population 1,384, Hatnur Lat. 20° 9' Lon. 75° 15', population 1,092, and Chapanor, Lat. 20° 10' Long. 75° 6', population 527, are the chief and largest of the British villages in the Kanad taluka. They are prosperous and enjoy a temperate climate, as among other produce they are able to grow grapes and oranges, which cannot be done in the plains of Khandesh.

Forts—Bhámergarh.—Sheet 36.

Of forts properly so called, there are none now extant, but the remains of what must at one time have been a place of considerable importance still exist in the big fortified hill called Bhámergarh. The town of Bhámer lay at its foot some four miles south of Nizámpur, and was evidently a place of some antiquity at one time, surrounded by a wall of which very little now remains.

Extract from the Narrative Report of MAJOR J. R. WILMER, *Deputy Superintendent, Survey of India, in charge No. 5 Topographical Party, Mirzapur Survey,—season* 1882-83.

THE country surveyed in the Mirzapur district consisted on the whole of very hilly, intricate, ravine country, and except a small portion round the village of Gahawar, was uncultivated and covered with jungle. The climate is very unhealthy during the month of November, and even throughout December and January a thick heavy mist hangs about until near 9 o'clock in the morning, quite stopping all survey operations for the time. The soil consisting very greatly of sandstone is very porous; the beds of all streams and large rivers are nothing but sand with occasional rocks showing; consequently water soaks into the ground and is rapidly carried away, so that it is scarce during March, and in many parts not available after the first week of April. In consequence of this scarcity of water, most of the party returning to Mirzapur could not travel by the usual route, but had to make a detour of some three or four marches longer. The whole of this district of Dudhi has been already described in Mr. Connybeare's report, but as I do not find the above peculiarity of climate mentioned, I have here drawn attention to it. In that report will also be found a full description of the soil, rivers, inhabitants, their customs, &c.; also of the different kinds of crops grown on the different soils and different seasons of the year, and I find no difference between the pargana here described and that of Singrauli which is adjacent to it, and a small portion of which came under survey this year. The principal river met with was the Rihand; this has a very sandy bed, and is a shallow stream with many treacherous quicksands. There are ferries across this river, one due west of Marhi, another south of Gahawar, and one between Bijpur and Dhursandia. The river is fordable nearly everywhere after the rainy season.

Extract from the Narrative Report of H. Horst, Esq., *Deputy Superintendent, Survey of India, in charge No. 7 Topographical Party, Burma Survey,—season* 1882-83.

Remarks on the country plane-tabled.

The tract over which the detail survey operations extended is called the Thoneseh Forest Reserve, and is really the valley of the Thoneseh Choung—Choung signifying river. It is bounded on the north by the Moka reserve, the common boundary running along one of the main spurs of the Pegu Yoma range; on the south by the Okkan reserve; on the east by the Kunbilin reserve, the boundary running along the watershed of the Kunbilin and Thoneseh rivers; and on the west by the Pegu Yoma range. Between the ridge which divides the Kunbilin and Thoneseh reserves there is another high ridge which forms the watershed of the Thoneseh and Khadu-gweh rivers, the latter being a tributary of the former. The highest elevation attained in the detail survey was a hill called Chouktala, 1,323 feet above sea-level, which overtops the Yoma or *main* range. The nature of the country is extremely intricate, and when to this is added the density of the forest, the tangled mass of creepers—cane being the most formidable—scarcity of water as the season advances, excepting near the main streams, and the utter desolation, the difficulties the surveyor has to experience can better be imagined than described. The details are very minute, to generalize which considerable experience is necessary, as the view is completely shut out, even from the more commanding points, and the water-courses are so deep that without actually following up each stream it is impossible to tell which is of sufficient importance to survey. There being but two or three small villages inhabited by Karens, very great difficulty was experienced in getting guides. The Deputy Conservator of Forests at Tharrawaddy acted to the best of his ability in placing at the disposal of the party a forester and two rangers for the purpose of pointing out the boundaries of the reserves and procuring guides, yet the arrangement was not satisfactory, as those Karens whom they succeeded in persuading to act as guides were unacquainted with the ground. Moreover, they were hardly engaged before they deserted. The forest is extremely dense and almost impenetrable; far worse than anything of the kind in India, as the forest officers themselves declare. Every ray for the traverser or planetable surveyor has to be cleared, so that the work literally progresses by inches. The only clearances are those made by the Karens, which are few. With these exceptions, the country is a perfect wilderness, there being nothing to relieve the eye. After a time the silence and monotony become so painful that the longing for a change is beyond all description. The Burman cannot endure this, and it is only the European or the Hindustani who has sufficient perseverance to plod his weary way. For three months a fog quite as dense as any experienced in England out of London overhangs this desolate region. It lifts about 10 A.M., up to which hour there is a perpetual dripping from the trees and the undergrowth reeks with moisture, which soon causes fever and dysentery—diseases which none escape excepting those possessing the strongest constitutions. Gad-flies were a source of terrible annoyance; during the months of February and March they prevail in swarms and settle over the body, stinging through the clothes; their stings cause great irritation, and sometimes sores. One has not a moment's peace from these pests; even in a tent with chicks they will force themselves through the least opening and settle on their victim. The baggage elephants were fearfully tormented; their sides used to be covered with blood and they were driven half mad. On one occasion an elephant, to get rid of its tormenters, fairly rolled over with its burden; fortunately this consisted only of tents and two or three chairs, &c., so that there was not much damage done.

Principal pathways.

The most important pathways in the Thoneseh reserve are—first that from Le-padan to Phaioteh, which, after ascending the ridge which divides the Kunbilin from the Thoneseh reserve, descends into the Nattu Choung at its junction with the Khodugwe Choung, follows the course of the former for a mile and a half, ascends one of its feeders for another mile to its source, and entering a feeder of the Thoneseh Choung follows its course to its confluence with that river close to which the village of Phaioteh is situated. This is the best and most frequented path practicable for laden elephants, but not for mules or ponies, unless without baggage, and even then they must scramble up many parts. Second, a path strikes off from the one just described as it reaches the junction of the Nattu Choung, following up the course of the latter till its junction with the Kanmyoung Choung; keeping with this stream to its source, it goes to a village called Sambok. Third, a path from Weh to Phaioteh goes along the bed of the Thoneseh Choung, leaving it once for about two miles, and entering it again near Thoneza Teh. This path can only be used by elephants after January, and even then the water is so deep as to wet the pads.

Rivers.

The Thoneseh Choung is the largest stream falling within the season's operations. It takes its rise in the Pegu Yoma range, a little south of the G. T. station of Sanwinguntong, follows a southerly course right through the Thoneseh reserve as far as Weh village, situated on the edge of the cadastral work; still keeping a southerly direction for about six miles, it turns abruptly to the west, flows under the town of Thoneseh where the Rangoon and Irrawaddy State Railway crosses, and falls into the Mimakha close to the town of Sanyuay. No portion of this river is navigable, but it serves the purpose of floating down timber which during the dry months is collected in its bed and in the main feeders. When the rains set

in, the Thoneseh Choung becomes a roaring and resistless torrent, rising some 20 feet in a a few hours. Here and there along its banks are situated a few Karen villages.

The Khodugweh Choung rises from the ridge which divides the Moka Biling from the Thoneseh reserve in about latitude 17° 54′ and longitude 96°. Keeping a southerly course it is joined by several feeders, the largest of which is the Nattu Choung. It meets the Thoneseh Choung in about latitude 17° 48′ and longitude 96° 1′. This stream, as well as the Nattu Choung, is used for floating down timber also.

Inhabitants and their customs.

Karens are the sole inhabitants of the forest tracts; they are a sly race resembling the Burmans in features. Nothing will induce them to take up employment longer than a few days. Their villages generally consist of a single shed raised a few feet on posts, having a passage running down the middle from end to end with compartments on either sides. Each of these compartments constitutes the abode of an entire family, both sexes being huddled together; as many as 15 or 20 families occupy one shed. Below, on the ground floor, are kept their cattle, pigs, poultry, &c., and the entire habitation is extremely dirty. Being ignorant of the language, the customs and manners of these people could not be ascertained, but they are fully described in the *British Burma Gazetteer*. They are hospitably disposed, and when encouraged, come about the camps to render a little assistance in running up huts. The women are more interesting than the men, and better looking than their Burman sisters, having fairer complexions and more affable manners. They are said to be very chaste, cases of misconduct being rare. The religious belief of the Karens is a sort of Buddhism; they are open to conviction, and are glad to receive missionaries. The Roman Catholic Priest of Thoneseh frequently makes a tour through the villages, and is hospitably received by them. He has been pretty successful, and they welcome him heartily when he goes among them, placing all they possess at his disposal. They are honest to a degree, no attempt having ever been made by them to steal, although favourable opportunities were not wanting. The villages of these people are called *Teas*, named generally after the headmen, and after inhabiting them for about 12 months they burn them about the time of *Holi* festival which occurs in April, and erect fresh sheds which are entirely constructed of bamboos even to the very thatching. They are allowed to clear certain plots, where they sow paddy one season, and the following, plant out with teak seedlings, to which they are bound to attend till fairly advanced. Certain tracts called Karen areas are made over to them entirely, for which they pay no revenue on the produce, but each man owning a dha (a kind of chopper) or axe, has to pay one rupee annually. They sow barely sufficient paddy for their own consumption, obtaining all other necessaries from the markets on the line of railway, 25 or 30 miles away.

Carriage.

Local carriage is not procurable in the province; survey parties have therefore to depend entirely on elephants either belonging to the department or received on loan from the Commissariat Department on condition that all expenses for feed and keep are defrayed by them, and the value of the animals made good in case of death. To the Burma Topographical Party were attached 10 Commissariat elephants; no other animals could have answered so well. The surprising way they manage to scramble up and down narrow steep cuttings and steep hill sides is really wonderful. As there is always a risk in employing Commissariat elephants by reason of the liability of their being suddenly recalled in case of necessity, arrangements are being made to purchase four, while it is possible two will be transferred shortly from No. 7 Cadastral Party on their taking up fresh work in Akyab during the approaching field season. A few mules have been asked for on loan from the Commissariat, and it is probable the General Commanding the Division will give his consent, but it is doubtful whether they will answer as well as elephants. At the termination of the last field season one of the Commissariat elephants died suddenly, and the value had to be made good. Shortly after the animal died, it was surrounded by about a hundred Burmans with their dhas ready to operate on the carcass Immediately permission was given, they set to and carried away the flesh. In less than two hours nothing remained but the backbone and skull. Burmans have an idea that the flesh of an elephant is very strengthening, and would travel a long distance for a slice. This was not known at first, or the carcass might have realized from Rs. 50 to 100 by disposing of it to one or two individuals, who would have realized a good profit by the sale of the flesh.

Supplies.

Provisions were only procurable from the market towns of Thoneseh and Letpadan on the line of railway, a distance of from 25 to 30 miles from the scene of operations. When it is considered that from 300 to 400 men have to be provided with all the necessaries of life, the magnitude of the commissariat arrangements may be imagined. It was like feeding a regiment, only more troublesome, since about 18 camps were scattered over the Thoneseh and Moka Biling reserves, over an area of nearly 200 square miles. Depôts were established in three places, viz. Phaioteh, Weh and Yetho, and from them the several camps drew their supplies about once a week. Precautions had of course to be adopted to keep the depôts well stocked, as the slightest failure would have proved disastrous. A Chinaman was induced to enter into a contract to lay in a stock of provisions, but he objected to retail them away from the market towns; consequently they had to be purchased wholesale and sent to the depôts, where trustworthy chaprassies managed the retailing. The supervision of this business was more troublesome and caused more anxiety and worry than that of the professional work. These matters are so differently managed in India that no idea can be formed of the heavy task they impose on the executive officer.

Extract from the Narrative Report of MAJOR H. R. THUILLIER, R.E., *Deputy Superintendent, Survey of India, in charge No.* 8 *Topographical Party, Mysore Survey, season* 1882-83.

Description of country.

THE country triangulated embraces portions of the Kadur and Mysore districts, bordering on the Coorg and Wynád frontiers. The northern portion, sheets, 51, 52 and part of 53, consists of the basins of the Hamávati river (one of the principal tributaries of the Cauvery) and of the Cauvery river. This tract consists of open undulating country with scattered hills; it is generally cultivated and populous, and in every way favourable for trigonometrical operations. The southern portion, however, sheets 53 (part), 67 and 68, comprising the greater portion of the Heggaddevankote taluk, consists of mountain ranges covered with vast and dense forests, the haunt of elephants, tigers and other wild animals. This tract is notoriously unhealthy, and altogether presented formidable obstacles to reconnaissance. In this area are the following State forests:—Aimur, Márigudi, Begur, Kákankote, Viranhoshálli, Metikuppa, and Hunuoxkoppa, which contain valuable teak timber. District forests have also been formed at Puduvokote and Janapanhali. Through this wild forest tract flow the Lakshmantertha, Tarkaun, Kabbani and Nugu rivers, which all fall into the Cauvery. The detail surveyors will certainly experience great difficulty in surveying this part of the country.

The country plane-tabled this season was similar in physical features to that met with last year, a portion being in the "Malnád" or hill forest region, and the remainder in the "Maidan" or open country. Sheets 1, 2, 4 and 5 belong to the first-named region. These sheets comprise the greater parts of the Ságor, Sorab and Shikarpur taluks of the Shimoga district, the western side of which is bounded by the ghâts. The whole of this region abounds with mountain wilds clothed with luxuriant forest. The portion in sheet 2 is extremely rugged and difficult to move about in, requiring very light equipment and a great amount of physical exertion, energy and patience, to execute the survey. The drainage runs into the Sharávati river, which flows in a north-westerly direction through the sheet until it reaches the frontier, where it bends to the west and precipitates itself down the famous falls of Gersappa, and discharges itself into the sea at Honáwár in North Canara. As an account of these remarkable falls will be of general interest, I give it as described in the *Mysore Gazetteer*, Volume II, pages 387-390: "The magnificent *Falls of Garsappa*, or the Jog, as they are called by the natives, are unquestionably the grandest natural beauty in Mysore, rich as it is in splendid scenery. They eclipse every other fall in India and have few rivals in any part of the world. While excelled in height by the Cerosoli and Evanson cascades in the Alps, and the falls of the Arve in Savoy, the Gersappa cataract surpasses them in volume of water precipitated; and while much inferior to Niagara in volume, it far excels those celebrated falls of the new world in height. They are situated in 14° 14′ N. lat., and 74° 50′ E. long., on the borders of Mysore and Canara, 60 miles from Shimoga in the former and 30 from the port of Honáwár (Honore) in the latter. Their existence appears to have been unknown at the time of Buchanan's journey in 1800. The Sharávati, flowing over a very rocky bed about 250 yards wide, here reaches a tremendous chasm, 960 feet in depth, and performs (as Captain Newbold has expressed it) this stupendous lover's leap from the chains of the giant ghâts into the arms of his ocean-rescued mistress—prolific Canara.

"The water comes down in four distinct falls, presenting a scene of transcendent grandeur and sublimity, whose effect is greatly heightened by the wild and beautiful country around, covered with a wealth of luxuriant vegetation. The Rajah fall pours in one unbroken column sheer to the depth of 830 feet. Half way down it is encountered by the Roarer, another fall, which precipitates itself into a vast cup, and then rushes violently downwards at an angle of 45 degrees to meet its famous compeer. A third fall, the Rocket, shoots downwards in a series of jets, while the fourth, called the Dame Blanche, is an Undine-like cascade gliding quietly over the mountain side in a sheet of foam.

"The most favourable time for visiting these glorious works of nature is in the cold season, when the river is low enough to admit of crossing to the Mysore side, whence the best views are obtained. During the monsoon the place is enveloped in a dense cloud of vapour, through which rises the thunder of the invisible mighty waters in their fearful descent. There is a good bungalow on the Bombay side, immediately at the head of the falls. Close by is a slab of rock projecting over the verge of the gulf, by lying down on which and peering over, the best view is obtained of the appalling abyss from above, rendered more striking by the continual flight across it of myriads of rock pigeons, which find a congenial home in the face of the cliffs.

"The falls are seen to greatest advantage from the selected points of view which have been cleared on the Mysore bank, the most popular being Watkin's platform. From this side a descent may be made to the pool below, the water in which is 130 feet in depth. But this is a difficult undertaking, and the re-ascent extremely laborious. The view, looking upwards from below, is generally considered far less impressive than from the other points as regards the falls themselves; but the grandly rugged features of the chasm, and the winding gorge in which it is prolonged, are more clearly seen in all their savage nakedness.

"The varying effects of light and shade at different hours are extremely beautiful. A lovely rainbow spans the waters in the afternoon, rising with the declining sun, and even lunar rainbows are said to be formed in certain aspects of the moon. Rockets and blazing torches or bundles of straw cast over on a dark night, throw out a fitful glare upon the jaws

of the abyss, producing weird and solemn effects as viewed from the Rajah's rock. No words can suffice to adequately describe the charms of a scene replete with every element of the sublime, combining in one superb panorama so many varying aspects both of terror and of beauty, all instinct with the life, the force, and play of moving waters.

"The precipice over which the water falls, affords a fine section of gneiss and its associated hypogene schists, which dip easterly and northerly away from the falls at an angle of about 35°. The gneiss is composed of quartz and felspar, with both mica and hornblende, and alternates with micaceous, talcose, actinolitic, chloritic and hornblende schists, imbedding (especially the latter) iron pyrites. These rocks are penetrated by veins of quartz and felspar, and also of a fine-grained granite composed of small grains of white felspar, quartz and mica. The mass of hypogene rocks has evidently been worn back several hundred feet by the erosion and abrosion of the cataract; the softer talcose and micaceous schists have suffered most. Rock basins are frequent in the bed of the river, which is worn in the rock and rugged with water-worn rocky masses."

Two officers of the Indian Navy, deputed by Government to measure the falls, arrived there on the 6th of March 1856. Their account of the feat, written in the old bungalow book, is as follows :—

"Threw a light flying bridge across the chasm from the tree overhanging the Roarer to the rock westward of that, called the Rajah's rock. To this slung a cradle of light bamboo, capable of holding two people comfortably. The cradle traversed on one single and two double blocks, through which rove the four hawsers composing the bridge. We had previously placed the bridge from the Rajah's rock to the tree, but found that the lead-line would not, from any single part of the bridge, plumb clear of the Roarer or the rocks on either side, thus proving beyond a doubt that the pool had never before been plumbed from the sides of the chasm.

"In the forenoon of the 12th of March, all arrangements being completed and provision made against remote contingencies, we made the passage in the cradle from side to side, halting in the centre to pour a libation to the guardian spirits of the chasm. The arrangements being found perfectly satisfactory, we proceeded to plumb the pool. The cradle, with one person, was eased away to a distance of 47 feet from the tree. The lead-line was lowered from the shore through a block (*vulgo*, a pulley) on the cradle, passing down through its centre. The plummet consisted of seven pounds of hard lead placed in the centre of an annular life-buoy slung horizontally, the whole weight being about 18lbs. When the lead reached the pool, the life-buoy floated it, and thus the leadman in the cradle felt the loss of weight. Having during our service had a little experience in deep water, we knew that a loss of 20lbs from a plumb-line of upwards of 100 fathoms would be scarcely appreciable, and so we found it. But by hauling up half a fathom and letting go suddenly, the life-buoy made a discernible splash in the water. A mark was then placed on the line by the block, and the angle of its dip taken with a theodolite on the brink of the precipice near the tree, at the hypothenusal distance of 47 feet. This gave the perpendicular depression of the cradle below the instrument (on a level with the tree) as 14 feet, which, added to the line paid out, 815 feet, gave the exact depth, 829 feet.

"In the afternoon we descended the ravine, and with a raft of a few bamboos and three boats' breakers, paddled and sounded all round and across the pool, having previously, from above, turned off a great part of the Roarer into the Rocket. We found that 22 fathoms was the greatest depth anywhere. This sounding was taken very near the west side, about 30 yards from the head of the pool or base of the Grand Fall. We climbed the rock on which the Roarer falls, and when about 30 feet up it, the stream, which before had been mild rather, came down with great force on our devoted heads, and we had to 'hold on by our eyelids' to prevent being washed off.

"By measuring a base we ascertained the horizontal distance between the centres of the Canara and Mysore bungalows to be 710 yards; between the Rajah's rock and the tree that plumbs the Roarer, 74 yards. The top of the Rajah's rock is five feet below the level of the above-mentioned tree. A plumb-line lowered from this tree into the bed of the Roarer, measured 815 feet.

"On the 15th of March, broke up our bridge, from which we had taken several satisfactory views of the chasm, and descended by a rope into the cup of the Roarer, where we breakfasted, and afterwards, with some little difficulty at one point, passed down by the side of the Roarer and reached a position at the back of the Grand Fall, whence the Rocket and Roarer were seen to the right of it. From this place only can you have a correct idea of the great depth of the cavern in front of which the Grand Fall drops. The sky clouded over and thunder pealed when we were below. The effect was grand in the extreme. At 5 P.M. reached the top of the cliff in safety."

The ground in sheet 4 and in the north-western part of sheet 5, comprising the Sorab-taluk, although belonging strictly to the Malnad, varies very considerably from that in sheet 2, both in vegetation and physical features, as may be seen from the following description from the *Gazetteer* :—"The woodland scenery of the Sorab-taluk is unique on account of the patches of forest called *Kans*. These are composed of the finest forests to be found in the south of India, detached in small portions with clearly demarcated lines. This arrangement is due to the position of the laterite which forms the substratum of the whole taluk. Outside the forest, on the higher ground, the soil is only about 4 inches in depth; while within, 15 feet from the edge, it is deep and rich enough to support the largest forest trees These evergreen forests are full of the wild pepper vine." The ground is of an undulating nature, but

the southern and eastern portions of sheet 5 are very hilly and covered with dense and heavy forest. The work in these four sheets, 1, 2, 4 and 5, comprising an area of 1,308 square miles, was executed by European assistants, and had to be done almost entirely by traversing with the plane-table and chain.

The country in sheets 55 and 56 of the Mysore district is mostly an open undulating plain, populous and generally well-cultivated, with fine chains of tanks. Here and there are ranges of hills and isolated peaks forming prominent landmarks, some of which are celebrated for their historical and traditional associations. The most important of these are the sacred hill and temple at Melkote, and the rocky hill of Chandrabetta at Shravanbelgola. The former is 3,548 feet above the sea, and commands a fine view all round. It is one of the most celebrated places of Hindu worship, and has a number of religious buildings, one of the principal of which is Narasimha temple, built on the very summit of the rock. The rock at Shravanbelgola is noted for the colossal Jain statue of Gomatesvara, about 60 feet high, on its summit. It is supposed that this image was cut out of the living rock, and, from the inscription at its foot, was made by a certain Chamunda Raya, who is said to have lived about 50 or 60 (B.C.). With the exception of the side facing the south-west, which bears the brunt of the monsoon, the stone looks as if it had been freshly cut.

Extract from the Narrative Report of MAJOR T. H. HOLDICH, R.E., *Deputy Superintendent, Survey of India, in charge Kohat Topographical Survey,—season* 1882-83.

Remarks on the country plane-tabled.

THE country plane-tabled has already been pretty fully described in last year's report under the head of country triangulated. It is chiefly the eastern part of the Kohat district bordering the Indus. A strip of country on the right bank of the river, from 6 to 10 miles wide, extending from near Attock to a point some 5 or 6 miles north of Kushalgarh, forms the extreme north-east section of the Kohat district. The northern boundary of the strip is formed by the hills dividing it from the Peshawar valley, crossed by the Beragash, the Mirkilan and the Cherat passes. The last-named is an inferior road leading up to the cantonment of Cherat. The two former are much-used routes, practicable for laden camels. Of the two, the Beragash (called Sunniali in old maps) is the better one and the most direct route to Naoshera. All this country is peopled by the Akhora Khattak section of the great Pathan family, who extend down to Kushalgarh. The soil is rough sandstone, much cut up by ravines and only affording occasional opportunity for cultivation. The western boundary from a point opposite the Ghoratap (or horse's leap) where the river turns suddenly south, is formed by the Afridi hills, whence extend long limestone spurs (the Nilabgash and Landaki hills) right across it to the Indus. These spurs are of no great height, and are now traversed by easy passes, which carry the main road from the south country across them to Attock. Southward and westward from Kushalgarh, the Kohat district widens out into more open plains for the most part destitute either of cultivation or jungle. The sandstone formation still continues along the right bank of the river, and throughout a considerable width of country presents a most intricate mass of topographical detail. Narrow, sharp-edged sandstone ridges, all with a north-easterly and south-westerly run, and packed in parallel bars as close as they can lie, are intersected and traversed by deep, narrow ravines, along which the drainage of the country finds its way in occasional torrents and rapids. As a rule, however, the minor watercourses are dry, and even the big lines of drainage, such as the Kohat-towa, hold very little water in the cold weather. Bordering the Kohat river and southwards from Gumbat to Dhoda and Lachi, on the main road to Bannu, is a fair amount of cultivation, most of it consisting of very fertile and highly irrigated ground. The culturable area hereabouts (towards the centre of the district) might possibly be extended by increased irrigation, but throughout the southern and south-eastern parts of the district it is probable that every acre of culturable ground is already taken up. The Sagri section (south and east of Shakardarra) of the district comprises little, but rolling sandstone hills and the low, broken sandstone country bordering the river Indus. One or two remarkable limestone peaks and ridges pierce the sandstone on both banks of the Teri river, which forms the northern boundary of Sagri. Two of them, Qund Hokhanni and Sukawur Hokanni, are landmarks for the whole district. But the most remarkable of the limestone hills are those which culminate in the peaks called Prangzai and Torgaghur (4,500 feet above the river), and which stretch out westwards towards Kummer and Maidan, and southward to Kalabagh. In combination with the Shinghur (a sandstone range) these chains of stupendous cliffs and crags form a most remarkable district, called Munzai, which is traversed by the Cniehalli pass connecting the more open northern country with Kalabagh. For rugged grandeur and wildness of mountain scenery I know nothing to compare with this Munzai country. Between Munzai and Sagri, a corner of the Bannu district (called Bangi Khel) interpolates itself. Down the length of Bangi Khel from Shakardarra to Kalabagh, runs a fairly good pass, but it is entirely within the limits of the Bannu district.

Extract from the Narrative Report of COLONEL C. T. HAIG, R.E., *Deputy Superintendent, Survey of India, in charge Guzerat Party,—season* 1882-83.

Description of country finally surveyed, sheets 40 and 41.

THE three tracts making up the area surveyed this season are very different in character; about one-half of sheet 40 and about 100 square miles in sheet 41 are hilly country; the hills for the most part consisting of long ridges parallel to each other and of about uniform height, that is, from 350 to 400 feet above the plain, and covered with forest. In sheet 40 there are some open patches of ground, but the greater part of the plain is covered with teak jungle, and in sheet 41 almost entirely so.

The river Mahi crosses the western half of sheet 40 diagonally from north-east to south-west. The river Pánam flowing from south-east to north-west enters both sheets and flows into the Mahi about seven miles above the point where it leaves the western margin of sheet 40. The Kun river flows from east to west across sheet 41. This also flows into the Mahi a few miles outside sheet 41. These three rivers constitute the main drainage of the country, and are formidable obstacles to traffic, as they can only be crossed at certain fordable points. The Mahi is of course much the largest of the three. Besides these, there are very many smaller streams and feeders which had to be surveyed and gave great trouble on account of the dense forest through which they invariably ran.

Godhra, the chief town and civil station of the Panch Mahál Collectorate, with a population of 11,448, is situate in sheet 41. The B. B. and C. I. Railway branch which, when sheet 27 was surveyed, extended only to Pâli in that sheet, has since been carried as far as Godhra. A metalled and bridged road runs eastward from Godhra to Dohad in sheet 53, and there are good, broad and straight roads partly bridged but not metalled, one joining Godhra with Lúnávâda (population 8,831) to the north, distance 24 miles, passing the town of Sehera (population 1,938), distance 12 miles, the other joining Godhra with Sunth (population 622), distance 42 miles, to the north-north-east from Godhra, but of this distance 13 miles are along the Dohad road. Lúnávâda and Sunth are chief towns of States under the Rewa Kántha Political Ageney, but about a mile to the east of Sunth the large town of Rámpur has sprung up, and now has a population of 2,561, and is practically the chief town of the Sunth State, which also now is popularly called Sunth Rámpur. Sehera is in British territory under Godhra. In the north-west corner of sheet 40 is the town of Virpur, population 3,542, pertaining to Bálásinor, a Rewa Kántha State, the chief town of which is in sheet 27. All these places are approximately correctly shown on the index map. The State town of Sanjeli (population 799) is shown on the index map as just within sheet 40, but this is erroneous; it lies about a mile to the east of the margin.

Description of country finally surveyed: sheets 18 and 37.

The country in sheets 18 and 37 is very similar to that of those immediately to the north, except that there are a few more hills in sheet 18 The Damanganga river, which rises in the ghâts and flows in a north-west direction and falls into the sea at Daman, is for the most part the boundary of the Thána Collectorate; and the Pâr river just crosses the north-east corner of the work in sheet 37, and between these flows the smaller river Kolak, and between it and the Pâr river is the Kothal creek. The drainage into these consists of a number of tortuous water-courses which caused considerable labour to the surveyors.

The Portuguese town of Daman, divided by the Damanganga into Great and Little Daman, is on the coast in sheet 18 It has a population of 9,195; and Little Daman is connected with Daman road station of the B. B. and C. I. Railway by a good metalled and bridged road of seven miles. A ferry constantly plies between Little and Great Daman. The latter is really the smaller of the two, its greatness consisting in its having a fort and containing the Governor's residence.

Besides the Daman road station situate near Wâpi, a large British village with a population of 1,746, there is the Udváda station on the railway seven miles to the north, the town of Udváda being on the coast three miles from the railway and connected with it by a good fair-weather road. Udváda has a population of 1,977; and a mile to the south at the mouth of the Kolak river is the town from which the river takes its name, with a population of 1,617. Close to the railway, about half way between the two stations abovenamed, is the old fort of Bagvâda on a commanding hill of about 150 feet above the plain. The villages in these sheets like those to the north are greatly broken up into groups of Bhil huts, causing much trouble to the surveyors. The metalled road from Pârdi to Dharampur and Násik passes through the north-east corner of the work in sheet 37.

The Dángs and Násik villages.

The character of the country surveyed in the Dángs is much the same as that of the previously surveyed area. The water was better and more plentiful than in the area surveyed in the preceding season. The carriage was entirely by coolies, but in the outlying villages of the Násik Collectorate surveyed on the 4-inch scale, carts were available.

Extract from the Narrative Report of LIEUTENANT-COLONEL A. PULLAN, S.C., *Deputy Superintendent, Survey of India, in charge Kattywar and Cutch Survey,—season* 1882-83.

General features of the country.

OF the country topographically surveyed this season sheets 6 and 7 proved the most difficult owing chiefly to the number of deep tidal creeks which intersected the western plane tables; the difficulties were considerably enhanced by the existence of very dense growth of mangrove bushes along the banks of those creeks, which rendered plane-tabling a laborious task. The eastern portion of these sheets also proved troublesome, owing to the number of ravines and low rocky hills which extend through them. The tops of these hills are for the most part covered with scrub jungle mixed up with long grass, offering very difficult ground to the explorer. Sheet 6 contains two important places, viz. Mátánomadh (or Mhur) and Náráyen Sarovar (or Naransar). The former is noted for the large Alum works which existed for many years near the town and is also celebrated as a sacred place of pilgrimage: it has a population of 961 souls. Naransar lies at the mouth of the Khori creek, and is principally inhabited by religious mendicants and priests. It has a population which increases and decreases according to the season: at the annual fair held during the month of November, as many as 6,000 persons are assembled in the town and its neighhourhood. Sheet 7 contains only two large towns, viz. Tera, population 3,529, and Naliya, population 5,265.

Sheet 8 contains a flat and highly cultivated plain; the towns of importance are Jakháu, population 4,872; Kothára, population 3,410; and Suthri, population 2,290. The first-mentioned town has a *bunder* or wharf situated about 3 miles west on the Goria, creek, where a small trade in timber, &c., is carried on between Bombay, Zanzibar, and Kurrachee. The coast line which runs through this sheet is firm with a sandy shore, and offers but few obstacles to the surveyor.

Hills.

The hilly ground is confined to sheets 6 and 7, the hills being low and rocky, covered over two-thirds of their area with thorny brushwood and varying in height from 200 to 900 feet above sea-level. The highest elevation is attained by the hill Sura-Gundára, which rises abruptly 893 feet above the sea.

Extract from the Narrative Report of LIEUTENANT-COLONEL H. C. B. TANNER, *Deputy Superintendent, Survey of India, in charge Darjeeling Party,—season* 1882-83.

ALL arrangements for the survey operations on the Nepal boundary and in the Darjeeling district were made by the late Captain Harman, from whom I took over charge shortly before the commencement of the field season; and I had merely to carry out his programme.

We had a tiresome and uninteresting march along the neighbourhood of the British and Nepal boundary until we reached the Koosee river where Mr. O'Sullivan's operations commenced. Numerous sluggish streams with steep mud banks had to be crossed, and the half-dried morasses left by the late rains were met with every few miles, and constantly retarded the progress of our carts.

As we proceeded westward from Siliguri, through northern Bengal, and entered Bahar, a gradual, though well marked, improvement in the physique of the inhabitants became evident, until in the Chumparun district (the most northwesterly of the Bengal Presidency) the men seemed quite as robust as the inhabitants of the Dekkan and of the Central Provinces; a great change for the better was noticeable also in their dwellings.

Mr. O'Sullivan's survey of the Bengal-Nepal boundary commenced on the left bank of the Koosee river, near a point where the survey of the late Captain Samuells was relinquished in 1875, and continued along the boundary of Nepal to the westward as far as Senaria in Chumparun, a distance of 182 miles including branch traverses. He was accompanied along the border of the Nepal zillas of Sabtari and Mohotari by Subah Krishan Lal Murbhari, and along the boundary of zillas Surlai and Raotat, and part of Bara zilla by the Lieutenant Baktawar Singh of Kararbana. Both of these Nepalese officials were most civil and obliging.

Mr. O'Sullivan closed his work on the 24th May, after having performed a most creditable season's operation.

Messrs. D. Atkinson and R. W. Senior had been selected for the survey of the western section of the Bengal-Nepal boundary, and I met the former officer at Biknatori on the 12th of January. Previous to my arrival he had cleared a ray of the North-East Longitudinal Series between the tower stations of Rámnagar and Tarharwa from which base the triangulation of the Sumesar hills was to be made. We fixed by triangulation, a point close to Biknatori from which Mr. Atkinson started his traverse of the boundary. He commenced the work in the middle of January, and finished off on Mr. O'Sullivan's closing point on the 10th of June; having in the period completed a detail survey for a distance of 128 miles, including a traverse of 108 miles along the boundary. Mr. Atkinson's maps are very neat, and his rather slow progress may be accounted for by his ill health. He was accompanied by a writer, and I was hopeful that this man would have soon picked up plane-tabling; but Mr. Atkinson reports that to the very end he was of hardly any assistance, and he had to conduct both the theodolite and plane-table survey himself.

In conjunction with Mr. Senior I now commenced the triangulation and reconnaissance map of the Sumesar hills which extended from Biknatori in the east to Tirbeni Ghat on

the river Gunduk to the west, a distance of 50 miles. Without knowing what was before us the task seemed an easy one, but before long we soon discovered that difficulties, at first quite unforeseen, would prolong our operations till the end of the season. In the first place we could get no guides to shew us the boundary or to point out the forest paths leading to it, and in the second we found that the engraved map was very misleading.

The Sumesar group or range differs only in one or two respects from the well known Siwáliks of which they are merely an extension. In the first place the Cheer pine (*Pinus longifolia*) is entirely absent, and in the second, the streams which tap the tract have from their very commencement a quiet and gentle flow. The steep boulder strewn ravine which the road crosses and re-crosses so often when proceeding to Dehra Dún by the Mohan pass has not its like in the Sumesar hills, but instead we find soft sandy beds and clear gentle streams with many deep pools. The track to Sumesar fort passes through a very wild valley which may be considered typical of all others in these hills. In one place the scenery is very striking: high white sandstone cliffs rise out of the streams, and appear to block the way in all directions, and the traveller has to wade nearly waist-deep between sandstone scarps which in one place leave a passage only ten feet wide. Ferns and graceful trailing plants grow luxuriantly on the moist cliffs near the water edge, and high overhead the hill tops and ledges are fringed with forest trees. But the wood-cutter is at work, and will soon strip these wild valleys of their sylvan charms. There is comparatively little game. Tigers abound, but deer are rare owing to the confined nature of the valleys and the innumerable scarps which prevent their wandering at pleasure amidst the hills.

Previous to my arrival at Sumesar on the 22nd January, Mr. Senior had selected a trigonometrical station and cleared the hill top. There is now but little to indicate that this was once the stronghold of the ancestors of the present Rája or zemindar of Rámnagar. A few remains of walls and a ruined temple (the veritable Sumesar itself) are all that is left of the fort. The situation was probably selected to hold the chief pass connecting the plains of Behar to the south with the open Nepal valleys of the Gunduk (or Naraini) and Rápti to the north; it commands of its kind, perhaps the very finest panorama of snow mountains on the globe. They form an unbroken line through an angle of 120°. The point of view is 2,884 feet above the sea and 2,000 above the plain immediately at the northern foot of the Sumesar hills, and is sufficiently lofty for the line of sight to clear a range of some 5,000 or 6,000 feet which backs up the Gunduk plain at a distance of about 25 miles. Immediately to the north and at the foot of this low range lies Deoghát, just in the mouth of a gap through which the Gunduk river makes its way. Close behind this gap no less than five snow-fed rivers meet; they drain almost the whole of the great mountain tract visible from Sumesar, and their united waters having made their exit by this aforesaid gap behind Deoghát, flow west and then south-west through the Gunduk plain, and finally emerge from the Sumesar hills at Tirbeni. The Rápti river which is not snow-fed, rises in the flat topped oak-clad hills towards the east, and joins the Gunduk 20 miles from Sumesar towards the north-west, but the point of junction is hidden behind low forest clad hills. Bright gleams of water here and there reveal the course of the rivers in the Gunduk plain, and with a telescope, in very clear weather, the villages may be seen right up to the foot of the hills. The limit between the forest and cultivated country is well marked, the former giving a dark shade to the tracts it occupies, wheras the cultivation appears as a broad light-colored ribbon striking the view and dotted with many groups of village trees. The eastern and western landscapes are occupied by an irregular mass of low forest-clad spurs of the Sumesar range backed up by the confused ranges which encircle Katmandu on the one side and Tirbeni on the other. To the south rise the white-faced sandstone needles and ridges of the spurs of Sumesar until they merge into the plain of Gobardhana and the Pipra Dún, or elevated plain of Pipra. The view to the southward extends on a clear day, far into Behar, and is bounded by a horizon as straight as that presented by the ocean.

Innumerable glistening threads of light point out the courses of the rivers of the plains and those peculiar vermicular marshes left ages ago by the hill streams when changing their courses. But from Sumesar the chief attraction to the traveller must always be the imposing wall of snow mountains which appear to rise immediately behind the dark colored range which stretches right across the north of the Gunduk valley. Nowhere through the gaps or the depressions of this intermediate range is any peak visible that does not belong to the snowy chain, which, though it looks so close, is from 80 to 100 miles distant, and in this respect the topography differs from that in any other section of the Himalayas. Towards Eastern Nepal, Sikkim, and Bhutan, the spurs of the snow-clad range gradually descend from the highest altitudes until they dip into the plains, and the higher spurs almost completely block up the view of the snows behind them. Again, towards Western Nepal, Kumaun, Mussooree, and up as far as Jummoo, the snows are only here and there visible, peering up behind the temperate hills. But from the Sumesar range one great serrated wall of dazzling whiteness fills one-third of the horizon. So far away are these mountains that the low intermediate range hides all the broken snows, and thus we have a most unusual and at the same time a most magnificent landscape containing all the elements of beautiful scenery.

Though the temperate mountains of Nepal, as far as I have seen them, are rather tame in their outline than otherwise, yet their very monotony serves to add grandeur to the lofty Himalayas, which at some distance behind them cleave the sky with huge needles, cones, and peaks to the last degree bold and wild in outline. It is, however, only the Himalayas which lie nearest the plains that maintain this rough rugged character, for the mountain tops which are here and there visible far up the valleys, near or on the watershed which separates India from Tibet, are round and smooth, and present an appearance like English downs

after a good fall of snow. The three points we have fixed on the Indo-Tibet watershed have an average of 22,000 feet. They are situated, one at what I believe to be the head waters of the Marsinghi river, one near the head of the Tirsuli Ganga, and the third far up the Naraini, the greatest of the river system of the Gunduk basin.

Amongst the inhabitants of the plains of India the most profound ignorance and indifference prevail regarding the great mountain tract visible to them towards the north, and we were unable to obtain any authentic information regarding the Himalayas even from the Nepalese met with on the Sumesar pass, crossing over from Nepal to India. Towards the close of the season I came across an old man who had seen much service with the Nepalese army and had taken part in the wars with the Tibetans. He was an intelligent old fellow and quite competent to give me most valuable information concerning his country, but after getting him up to the top of Sumesar, a dense brown haze of dust and smoke enveloped all nature and hid every feature beyond four or five miles during the remainder of my stay on the hill. This haze is *the* difficulty, one has to encounter in carrying out a trigonometrical survey of the Central and Eastern Himalayas. It comes on about the beginning of December, and except for a day or two immediately after general rain, almost completely hides the mountains from view. In Kághán and the Western Himalayas, this haze prevails to some extent, and for a considerable time impedes operations. In Gilghit it is known only during a few days in the year, when the wind is in some particular direction, but all along the north of Bengal it blots out everything more than a few miles distant.

The thickness of this stratum of haze varies much at different seasons, and is far deeper during the hot months than during the cold. I am informed by Mr. Ryall, who worked during the winter season in Darjeeling at an elevation of between 8,000 and 12,000 feet, that at places over 9,000 feet the atmosphere was quite clear. I can only form a rough guess, but I should say that the haze never extends above 13,000 or 14,000 feet, if it reaches as high; its upper edge appears sharp and well defined when the eye of the observer is on a level with it.

At the end of January 1883 we had continuous rain for 48 hours, and for two days after the rain stopped, we had the most crystal-clear atmosphere. During this time, almost from morning till night, we were able to carry on our observations, but after this, the haze-bank became gradually more and more opaque, until at the end of the third day the air was so full of ponderable matter that our work stopped. On this, and on a subsequent occasion, I saw the formation of this stratum of haze. At first one jungle fire sent up a column of smoke, which rose almost straight from the earth, but directly it attained an altitude of, say, 9,000 feet, its upper progress was suddenly stopped, and it then spread out across the heavens as a perfectly horizontal line, its upper edge most sharply defined. As the number of fires increased, so the belt extended, and though it never spread into the pure air above, it gradually mixed with that below, until the view was quite shut off.

During the season we observed from five tower stations of the North-East Longitudinal Series, and from eleven hill stations selected by us on the Sumesar range.

The map of the Sumesar hill by Mr. Senior is for the present but a small scale sketch based on few plotted points. The tract is uninhabited, but during the healthy season, is alive with wood-cutters. None but Tharus, an aboriginal tribe who for the most part are the chief inhabitants of the Gunduk plain, remain anywhere in the neighbourhood throughout the year, and they live all along the foot of the hills just outside the belt of jungle. They share the Pipra Dún with Gwálas or cattle-breeders, and apparently enjoy an immunity from fever, which during the autumn is said to be most fatal to all who may attempt to settle in this tract. All along the forest tract which skirts the base of the Sumesar hills and extends almost over the entire area of the Pipra Dún, traces of recent cultivation are visible. The map of this Dún, executed in 1845-48 by the Revenue Survey, shews villages where now there is nothing but jungle, and though the larger forest trees are now being rapidly removed, yet the waste appears to be encroaching on the cultivation. In Bettiah, on the border of the jungle tract, I also found a state of things for which I was unprepared, namely, a great extent of land on which the boundaries of the fields were sharply defined as if they had been lately cultivated but now covered with coarse grass; it appeared to me, though I was informed that such was not the case, that here also the cultivation was receding before the advancing jungle. The large areas of grass and forest in this part of the country rendered the climate in the spring, quite delightful, and Mr. Senior states that at the very hottest time he was out the heat was never unpleasant.

There is no cultivation whatever near Tirbeni, and the forest comes down to the stream, the left bank of which has been worn into cliffs for some distance up. I returned from Tirbeni by the Puchnud stream, which to its source, forms our frontier. Here and there I came across whole families engaged in gold-washing. They first direct the stream by means of banks of shingle into a straight course, and then great and small move the surface gravel and sand down stream, scraping the bed with flat boards; when they have cleared the bottom for a couple of hundred yards the accumulation which the stream has helped to bring from above is washed on flat boards, and after a minute of dexterous shaking and washing, there remains in the centre a small patch of fine yellow gold-dust. It is a pretty process to watch, but the people have to work hard from morning till night to earn a livelihood by it. The hills in the neighbourhood are of the well known Siwálik formation, but are capped hereabouts with a thick stratum of red marl mixed with shingle.

The highest ground to the south of the Puchnud may be one or two hundred feet above the bed of the stream; it is a plateau of red soil which extends towards the south-east

for about 25 miles, and has an average breadth of some 4 miles. Towards the east it loses its cap of red marl, and the very soft sandstone below is cut up into innumerable steep ridges intersected by abrupt ravines. This region has long since lost its finer timber, and is now covered with thick jungle of moderate size. The sandstone of the Sumesar hills is so excessively soft that it appeared to me to be a wonder how it could stand the successive rainy seasons of so many ages. The rain even of a couple of years cuts it away to such an extent that you may see pebbles, dead sticks, and leaves which have protected the spots immediately under them and prevented denudation, so that they are supported on pinnacles of sand with perpendicular sides from six inches to a foot above the general surface of the ground around them, and yet the sandstone cliffs of this tract stand up sheer to the height of 200 feet or more, showing no disposition to fall, and landslips appear to be uncommon.

Mr. Senior closed work in the middle of May, but during the last two months of the season he did not once sight the mountains in his neighbourhood, and was unable to use heliotropes even unless flashed from a short distance.

From Chumparun I returned to Darjeeling, where the survey was progressing under Mr. Ryall, and during the second week in May I worked along the Sikkim Nepal frontier as far as Lampherám, a hill near the snows where the densely wooded slopes of the Darjeeling district are replaced by open rocky plateaux covered with grass and dotted with pines. At this point, which is about 13,000 feet above sea-level, we were overtaken and nearly overwhelmed by one of the most violent snow-storms I have ever experienced. A strong gale raged all night, and carried the snow-flakes almost horizontally with it, and the cold pierced us to the very marrow of our bones. A bleak wintry morning was succeeded by a mild afternoon, and the following day was clear. From the Lampherám hill the array of snow mountains is very fine, and the rock splinters and needles which pierce the flat snow fields below Kanchinjinga form a wild middle distance. Rising from a deep valley in front is seen the sloping plateau of "Yampung." Its base is pine-clad, but the summit is rocky with patches of grass and scored with much-used cattle tracks. The great mountain Kanchinjinga, 28,156 feet above sea level, from this point loses much of its grandeur, being to a great extent hidden behind the nearer snow-clad spurs of Kabru (24,000 feet), but Jánu mountain (25,300 feet), stands out most conspicuously. One of the gaps visible in the snows is probably the Wallanchun pass, the fort of which was visited by Hooker. Beyond this range a single snow peak about 25,000 feet high has been fixed. It is probably situated to the south of the Arun river, and possibly confronts the great snow peaks seen north-west from the Donkia pass by Hooker and described by him.

From Lampheram, Mount Everest is almost completely hidden by peak No. 13 (27,800 feet), but points on the spur which runs northward and from it, are visible, and I was able to fix peaks on this ridge. The ranges round Lampheram present a curious, smooth, appearance caused by the action of wind on the dense forests of rhododendron which here grow in a compact mass into which neither man nor beast can penetrate. Every tree of this forest is bound to grow exactly the height of its neighbours, for to throw out a branch a foot higher than those that surround it is to ensure its being cut off by the cold, but by adopting a system of mutual protection, the trees grow so thick that the mountain sides look all the world like a well clipped box or quick-set hedge. At the summit the rhododendrons are dwarfed and only a few feet high, but low down, when at about 800 feet below the trigonometrical station they mingle with the pines and attain a great size. It is said that there are more than seven different varieties, and judging by the wide range of color exhibited by the trees covering a small patch of ground, I can well believe it.

Of all points on the Eastern Nepal boundary, Sandakphu commands the most extensive and by far the most picturesque views. From this place Kanchinjinga is seen to the best advantage, and Everest stands well away from the great peak No. 13. Notwithstanding that it is 90 miles off, this great mountain and its fellow, the peak abovenamed, which is some 12 miles nearer, stand up from the surrounding snowy ranges in the most marked manner. Of the numerous travellers who visit Sandakphu in the autumn, few come away with a correct impression of Everest. Many do not see it at all and others mistake peak No. 13 for it. The latter has a remarkable cup-shaped hollow at the top, like a crater with the side nearest the spectator cut away; whereas Everest is a pretty symmetrical cone without any well marked features on its face. The most remote Nepal peaks visible towards the west are 120 miles off, and are seen through the depressions of the Everest group. They have not yet been fixed, but are supposed to lie somewhere on the left bank of the Bhotia-Koosee river and on the Indian side of the Indo-Tibet watershed. I think it no exaggeration to say that the view from Sandakphu is probably surpassed by none in the Himalayas, and certainly by none so easily accessible to the European traveller. I have been unable to ascertain the name of the peculiar umbrella-topped pines of this range, which certainly are not "Abies Webbiana," a tree which grows to a fine point and with the lateral branches, but a few feet long, which clothe the stem from the top to near the ground. The Sandakphu pine grows more like a cedar than anything else, and is unlike the "Abies Webbiana" of the Western Himalayas, as two trees can well be. No mountainous region I am acquainted with has so little game as this one, and no mountains of their height have so few crags and precipices. There are some rocks, notably at Sandakphu, Phallut, and Lampheram, but as a rule the whole of South Nepal, South Sikkim, and all Darjeeling, present nothing but rolling easy slopes, with bamboo growing as dense and thick as it does on the plains of Bengal, extending up amidst the pines to regions enjoying a climate as temperate as that of Europe.

Narrative Report, dated 30th September 1883, *by* W. H. COLE, ESQ., M.A., *Officiating Deputy Superintendent, third grade, on the operations of the Detachment in Kashmir and on Surveys in Dardistan and Kishanganga for the nine months ending 30th September* 1883.

THE operations of this detachment had for their immediate object the survey, as far as practicable, of the tongue of country known as Chilás, which extends from about 73° 45′ to 74° 38′ east longitude, and from about 35° 5′ to 35° 40′ north latitude, and which is bounded on the north and east by Kashmir, and on the south partly by Kashmir and partly by Kághán. The country cannot be entered by our surveyors because of the hostility of its inhabitants; and the only means of obtaining any geographical knowledge of it is by sketching what can be seen from the surrounding mountains which form its boundary, and by theodolite observations to any prominent points or objects. The work has of late been carried on by a native sub-surveyor, by name Ahmad Ali Khan.

The narrative furnished for the annual administrative report for 1881-82 brought up the account of the work to the end of 1882. Since then Ahmad Ali Khan was employed on mapping his work till the end of January, when he was given leave to visit his home with orders to return early in April.

The sub-surveyor left Dehra Dun about 10th April and proceeded to Kághán, where he arrived at the end of the month. He found, however, that the recent falls of snow completely enveloped the watershed forming the boundary between Kháguán and Chilás, where his season's operations were to commence: and repeated falls of rain while at Kháguán rendered it impracticable to make a beginning of the work for nearly another month.

On the 30th of May, Ahmad Ali arrived at the foot of the hill on which Sepat or Spat station (altitude nearly 15,000 feet above sea-level) had been fixed some years previously by the Hazára survey. Owing to the snow, which extended to the bases of the hills, the ascent of five miles to the station, which was attempted on two consecutive days, proved a formidable job, but the native surveyor was able to work on both days with his plane table. He could not, however, use his theodolite, because the snow was so deep that he could not find the station mark. He next descended to the Kunar river, which he struck at Seri: from this place northwards to the borders of Chilás the country is destitute of inhabitants. Following up the course of the river he was able, during the month of June, to observe angles with the theodolite at three stations on the watershed, and at the same time to continue his plane table sketching.

Finding the direct route from Gitidás *viá* the Kamukdori (Kankatori) Pass (13,389 feet) blocked by snow, he turned south-eastwards, and, crossing by the Núri Nár Pass into the Shárdi iláka of the Kashmir territory, struck the Kamukdori stream (one of the main head waters of the Kishanganga river) at Sorgan village. From here he went up the Kamukdori stream to the pass of that name, which is on the border line between Kashmir and Chilás. Fresh, though light, falls of snow impeded the native surveyor's progress, who on two occasions had to pass the night without his tent at an altitude of 14,000 feet and on a third at 15,000 feet. He, however, succeeded in getting angular measurements from two stations and a fair amount of sketching, and then proceeded *viá* the Shochar Pass (14,729 feet) into the Astor iláka of the Kashmir territory.

He next made his way up the Tashing valley, the glaciers in which lying as they do in the immediate vicinity of the great Nanga Parbat mountain (altitude 26,620 feet)—must have seriously taxed his energies to reach the Thosho Pass, which it was expected would furnish a good view into Chilás. The native surveyor twice ascended to a station about 500 feet in height above this pass, but was driven down again by snowstorms. At last, on the 15th and 16th August, he made further attempts, and this time he was able to bring back both angular observations and sketching. This disposed of the view from the south into the Chilás country, and Ahmad Ali then proceeded *viá* Astor to Uphambu station (altitude 15,630 feet) on the east of the tract to be sketched. Having finished his observations and sketches from this station, he advanced to Bunji fort, which he reached on 31st August.

During the next month the native surveyor was employed in taking observations at three stations on the watershed, whence a view of the Chilás country from the north-east is obtainable and in plane table sketching. As was to be expected, he was a good deal hampered by bad weather, and having to pass the night at his three stations he had to encounter falls of snow during the night, one of these stations being over 16,000 feet in height.

Notwithstanding, he worked assiduously, taking full advantage of every opportunity that offered for filling in the topographical details.

The outturn of work is very satisfactory, for although the native surveyor was able to define accurately only about six or seven miles of the Indus below what had been fixed before, and did not apparently get a view of the Chilás fort, yet his final work comes down so near the river (on the left bank of which the fort stands) that it practically narrows to a minimum the limits within which geographical information is still incomplete. The area sketched is about 2,000 square miles, and although the native surveyor has been directed to keep out at work as long as the weather will allow in order to fill in details where still wanting, specially towards the north-west of Chilás, the object in view already stands practically accomplished.

As the native surveyor is still absent, such local information as he may have acquired descriptive of the tract surveyed cannot obviously be furnished.

Extract from the Narrative Report of MAJOR A. W. BAIRD, R. E., *Deputy Superintendent, Survey of India, Season* 1882-83.

EVALUATION OF TIDAL CONSTANTS.

THE values of the several tidal constants which have been determined for various ports, during the past year, will now be given in the same form as hitherto adopted.

The tidal constants are divided, as usual, into two groups. One composed of the short period tides, the duration of which in no case exceeds 24 hours; the other of long-period tides, whose duration ranges from a fortnight to a year.

In the harmonic theory of the tides, the principal constituents of the short period tides are represented by fictitious stars, moving in circular orbits, at certain known velocities—the arguments of motion—in the plane of the Equator. They are usually indicated by the letters, S, M, O, K, &c. Each of these is in its turn, composed of a number of tidal constituents, also moving in circular orbits, but with different velocities, which are mutually related, those of the second and subsequent constituents being twice, thrice, or some integral multiple of the first. Their periods are determined in the following manner. When the revolution of the fictitious stars is performed, in, or about, 24 hours, the primary period is the one corresponding to the argument of motion of the star; when it is performed in, or about, 12 hours, the primary period corresponds to twice the argument of the motion of the star; the subsequent periods are fractions of the primary, corresponding to multiples of the velocity. The tidal constituents after the first are sometimes called semi-diurnal, ter-diurnal, quarter-diurnal, and so on, and the smaller of these are usually called *overtides*.

Every tidal constituent is expressed numerically by two constants, viz., R and E. R denotes the linear value in English feet, of the amplitude, viz., the semi-diameter of the orbit, which is equal to half the range between the highest and lowest levels of the constituent; E denotes the angular value of the "epoch;" it may be defined to be the number of $\frac{1}{360}$ parts of the period, or number of degrees of the orbit, which any tidal constituent has still to execute from the instant when the fictitious star crosses the meridian of the place of observation, to the instant when the constituent reaches its maximum.

The constants R and E of the tidal constituents are respectively distinguished by the subscripts 1, 2, 3, representing the relations of their periods to that of the primary period.

Three only of the fictitious stars, viz., S, M, and K, have more than one constituent of sensible magnitude. The constituent which causes any fictitious star to produce its greatest effect on the sea-level is rarely the first, and more frequently the second. The greatest effect of any single star is invariably produced by R_2 of M; afterwards usually by R_2 of S, and R_1 of K, (but in some cases the R of the long-period tide, called the solar annual, is even greater than either of the two last named constants): to the last named constant (R_1 of K) the phenomenon of *Diurnal Inequality* (which is so marked a feature in the tides, on the west coast of India) is chiefly due. The first significant constituent of M S is of the fourth period amplitude, R_4.

The first constant in the table for each port is A_0, which signifies the height of the mean level of the sea above the level corresponding to the zero of the gauge.

[*It may be here said once for all that the values of the linear quantities* A_0 *and R throughout these tables are invariably expressed in English feet.*]

But it has been pointed out by Professor Darwin that the "epoch" which was chosen for any tide was probably intended to have reference to astronomical considerations in such a way that the results of each year's reductions should be strictly comparable amongst one another; but it appears that this was never entirely carried out.

The values of the amplitudes of the lunar and luni-solar constituents are clearly dependent on the inclination of the moon's orbit to the equator, and consequently vary from year to year; and the amplitudes (R) hitherto given took no cognizance of this, consequently they had to be modified before being used in the "tide predictor." The reduction of the R, to H, will be made in future, *H being the mean amplitude of the particular tide or co-efficient expressed also in English feet.*

In determining the value of E the "epoch" it is first necessary to calculate what is called in the reductions "the uncorrected E" and to apply certain angles derived from the position of the sun and moon at the initial date of the observations; but the treatment was incomplete. In the arguments hitherto used, the values of ν (right ascension of the intersection of moon's orbit and equator) and ξ (the longitude 'in the moon's orbit' of the inter-section) were not taken into account; and it is only by the application of the *proper* values of the arguments at commencement, that the true values of "ϵ" can be calculated so as to be comparable year by year.

It is now proposed to present the co-efficients as follows:—viz—

1. To tabulate the R^2 as formerly and also to give the values of "ζ" in each case, ("ζ" being the old uncorrected "ϵ") so as to give the results of the analysis in the form $R_1 \cos(nt - \zeta)$.
2. Also to tabulate the H^1 and K^1, so as to give the results in the form $H \cos(\nu + \mu - \kappa)$: and the H^1 and K^1 will be strictly comparable year by year: *the* K *in this case being the proper corrected* "ϵ", and refers to a mean value of the particular tide.

Professor Drawin explains ν to be a linear function of the moon's and sun's mean longitudes, the mean longitude of the moon's and sun's perigees, and the local mean solar time, at the place of observation reduced to angle at 15° per hour ν increases uniformly with the time, and its rate of increase per mean solar hour is the N of the first method, and is called the speed of the tide.

It is supposed that μ stands for a certain function of the longitude of the node of the lunar orbit, at an epoch, half a year later than 0 hour of the first day. Strictly speaking "μ" should be taken as the same function of the longitude of the moon's node, varying as the node moves: but as the variation is but small in the course of a year, "μ" may be treated as a constant, and put equal to an average value for the year, which average value is taken as the true value of "μ" at exactly mid-year. Together "$\nu + \mu$" constitute that function which has been tabulated as the "argument of the constituent tide."

H, as previously explained, is the mean value in English feet of the semi-range of the particular tide in question, *f* is a numerical factor of augmentation or diminution, due to the variability of the obliquity of the lunar orbit: for all solar tides *f* is of course unity: and for the principal lunar tide M_2, $f = \frac{\text{Cos.}^4\frac{1}{2}\ I}{\text{Cos.}^4\frac{1}{2}\ \omega\ \text{Cos}^4\frac{1}{2}\ i}$ when ω = obliquity of ecliptic, and i = inclination of the moon's orbit to the ecliptic.

H is equal to $\frac{R}{F}$ and K is equal to $\zeta + \nu_0 + \mu$, if ν_0 be the value of ν at 0 hour of the first day.

It is obvious then that if the tidal observations are consistant, *H* and K should come out the same for each year's reductions.

VALUES OF THE TIDAL CONSTANTS, ADEN, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Aden:

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2*SM*
A_0	5·754	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_1	0·027	0·087	0·590	1·230	0·329	0·022	0·126	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_1	163°·96	153°·98	317°·63	117°·93	341°·44	113°·50	328°·00	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_2	0·699	1·002	.....	0·177	.....	.....	.....	0·051	0·418	0·027	0·049	0·061	0·003	0·042	.....	0·027
ϵ_2	248°·25	228°·08	.....	231°·09	.....	.....	.....	41°·15	230°·30	333°·42	291°·07	209°·99	96°·81	273°·57	.....	215°·39
R_3	.....	0·017	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_3	.....	159°·18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_4	0·002	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·011	.....	
ϵ_4	289°·80	277°·49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	163°·32	.....	
R_6	0·004	0·007	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
ϵ_6	185°·44	349°·82	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
R_8	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
ϵ_8	200°·54	55°·45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

Long-Period Tides.

Lunar monthly tide	... ...	$R = 0{\cdot}035$	$\epsilon = 17°{\cdot}90$
„ fortnightly „	... ...	$R = 0{\cdot}035$	$\epsilon = 31°{\cdot}32$
Luni-solar „	„	$R = 0{\cdot}010$	$\epsilon = 210°{\cdot}94$
Solar annual	„	$R = 0{\cdot}399$	$\epsilon = 346°{\cdot}98$
„ semi-annual	„	$R = 0{\cdot}069$	$\epsilon = 98°{\cdot}61$

The value of mean level of the sea (A_0) agrees well with that obtained from the first three years' observations, the value for 1881-82 being slightly higher than was previously obtained.

The amplitude of the main lunar tide (R_2 of M) is the highest value yet obtained; and it is remarkable about this tide that the values obtained since 1877-78 have been steadily increasing, year by year. This peculiarity is noticeable at all the tidal stations on the west coast.

The value obtained for the main solar tide agrees remarkably well with that obtained for the three previous years.

The value of the main diurnal tide (R_1 of K) is the least obtained at Aden. The amplitude of this co-efficient has been steadily decreasing since 1879-80, and this is also the case at Bombay and Kurrachee.

The smaller lunar elliptic semi-diurnal tide (L) bears a proportion to the main lunar tide of 0·032, which does not differ much from the theoretical value 0·028: the larger tide (N) as compared to the main tide is 0·261, which is considerably higher than theory would assign, viz. 0·194, but this has always been the case at Aden, and the value obtained for 1882-83 is the lowest proportion yet observed.

The evectional tide (λ) is 0·017 of the main tide, while theory would only give 0·007; but for the larger tide (ν) the proportion to the main tide, is less than the theoretical proportion, viz. 0·031 against 0·038, while for the last year the proportion agreed exactly with theory.

With regard to the main solar tide, the proportion (0·436) to the main tide is not very different from the theoretical proportion, viz. (0·465). The luni-solar declinational semi-diurnal tide (R_2 of K) is 0·107 of the main tide, while theory would give about 0·126 as the proportion: the former values of the tide agreed better in their proportion to the main tide than that obtained for 1882-83.

With regard to the diurnal tides, their proportions to the main tide as compared to the theoretical proportion are as follow:—

	Aden 1882-83.	Theoretical.
Lunar (R_1 of M)	0·054	0·036
Luni-solar (R_1 of K)	0·768	0·584
Solar diurnal declinational	0·249	0·193
Lunar (R_1 of O)	0 368	0·415
Lunar elliptic (R_1 of J)	0·057	0·033
Solar elliptic (R_1 of Q)	0·079	0·080

Thus it will be seen that *the diurnal tides at Aden are all, with the exception of the lunar-declinational* (R_1 *of* O), *greater in proportion to the main tide than the theoretical proportion;* and as regards the main diurnal tide, it is actually 50 *per cent greater than the theoretical value.* In former years it was found to have even a much greater value.

The lunar and solar over-tides are all very small, as has generally been found the case at this port.

With regard to the long-period tides, the lunar monthly, in proportion to the main lunar tide, is about one-half what theory would assign, and the lunar fortnightly is about one quarter the theoretical proportion. The luni-solar fortnightly has almost exactly the theoretical proportion to the main tide; while the semi-annual is very slightly larger in proportion to the main tide than it ought to be by theory.

The solar annual agrees well in amplitude with the values obtained in former years, and is about one-fourth of the main tide.

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Kurrachee:—

Short Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*2R*	*T*	*MS*	*2SM*
A_0	7·179	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_1	0·076	0·081	0·627	1·262	0·336	0·061	0·119	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_1	173°·64	146°·42	327°·27	128°·08	316°·34	129°·80	345°·26	.....	.....	.....	.....	.....	...	...	.....	.....
R_2	0·360	2·572	.....	0·248	.....	.....	.....	0·088	0·639	6°·029	0·214	0·083	...	...	.....	0·030
ϵ_2	324°·03	292°·40	.....	296°·91	.....	.....	.....	96°·19	276°·73	93°·32	261°·52	263°·12	...	...	.....	122°·91
R_3	.....	·055	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_3	.....	324°·00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_4	·012	·028	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	·030	.....
ϵ_4	12°·10	12°·55	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	324°·08	.....
R_6	·008	·051	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_6	313°·98	201°·22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_8	·000	·009	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_8	123°·69	248°·47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....

Long-Period Tides.

Lunar monthly tide	$R = 0{\cdot}057$	$\epsilon = 72°{\cdot}21$
,, fortnightly ,, ...	$R = 0{\cdot}031$	$\epsilon = 230°{\cdot}34$
Luni-solar ,, ,, ...	$R = 0{\cdot}044$	$\epsilon = 132°{\cdot}62$
Solar annual ,, ...	$R = 0{\cdot}100$	$\epsilon = 49°{\cdot}59$
,, semi-annual ,, ...	$R = 0{\cdot}116$	$\epsilon = 163°{\cdot}73$

The value of mean sea-level (A_0) is 7·179 feet, which is lower than any of the values for the four preceding years.

The amplitude of the main lunar tide (R_2 of M) is 2·572, which is the highest value yet obtained (with the exception of that from the 1868-69 observations by the old gauge) at Kurrachee.

The main solar tide agrees very well in amplitude with the values obtained in the two preceding years, and is not very different from any of the values obtained since the observations were commenced at Kurrachee.

The proportion of the main solar tide to the main lunar tide is 0·373, which is considerably less than the theoretical proportion (0·465), but this proportion differs very little from the values in the three preceding years.

With regard to the lunar elliptic semi-diurnal tides, the smaller component (L) agrees fairly well in its proportion to the main tide with what theory would assign; but the larger component (N) is about 25 per cent of the main tide against 19 per cent, the theoretical proportion: this does not materially differ from the values obtained in former years.

The smaller evectional semi-diurnal tide (λ) agrees closely in its proportion to the main tide with the theoretical value, and this was found to be the case in the two preceding years; with regard to the larger component (ν) the proportion to the main tide is more than double what theory would give; while last year it was only 50 per cent greater, and in 1879-80 this tide agreed well with its theoretical value.

The variational tide (μ) is about 3 per cent of the main tide, which is tolerably accordant with the theoretical value.

The solar-elliptic semi-diurnal tides have not been evaluated this year, as two years' observations are required for their reduction, and the observations in 1880-81 were combined with those for 1879-80 in determining the values given in the schedule of tidal constants for 1880-81.

With regard to the luni-solar declinational semi-diurnal tide (R_2 of K), the proportion to the main tide is 0·096 against 0·126, the theoretical value; while for last year the proportion was 4 per cent. greater than theory would give; and in 1879-80 this tide agreed precisely with its theoretical value.

As regards the diurnal tides, the largest (R_1 of K) is 49 per cent of the main lunar tide, while by theory it ought to be 58 per cent.

It is remarkable about this tide, that for the 5 years, from 1874-75 to 1878-79, the proportion obtained was precisely that which theory would give, and since 1878-79 the proportion has been gradually decreasing.

The second largest diurnal tide, the lunar declinational (R_1 of O), is for this year only about half as large as it ought to be in comparison to the main-lunar tide, but this tide has always been found to be considerably less at Kurrachee than theory would assign. The remaining diurnal tides (R_1 of P—R_1 of J—R_1 of Q) are respectively, about 4 per cent, 1 per cent and 3 per cent less in their proportion to the main tide than theory would give.

With reference to the over-tides at Karachi, they are much the same as in preceding years and are all much larger in their proportions to the main tide than generally obtains at open coast stations. The over-tide (R_4 of M) is double the quarter-diurnal tide, and this has been found to be the case in all the reductions of the observations at this port, now over 10 years.

As regards the long-period tides, the lunar monthly in proportion to the main lunar tide, is about half what it ought to be, while the lunar fortnightly is only 1 per cent of the main tide against 9 per cent, the theoretical value; but the lunar fortnightly tide has always been found very small at Kurrachee. The luni-solar fortnightly tide, which theoretically ought to be insignificant, has generally been found at Kurrachee double what it ought to be.

The solar annual tide is 4 per cent of the main tide, which is precisely what was found last year.

The semi-annual tide agrees fairly well in its proportion to the main tide with the theoretical value.

VALUES OF THE TIDAL CONSTANTS, KURRACHEE, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Kurrachee :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	7·060	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_1	0·005	0·111	0·578	1·227	0·330	0·070	0·118	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_1	171°·26	147°·24	326°·34	159°·27	314°·42	216°·22	342°·03	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_2	0·962	2·618	.....	0·197	.....	.....	.....	0·051	0·006	0·061	0·125	0·041	0·009	0·021	.....	0·022
ϵ_2	333°·56	292°·45	.....	266°·67	.....	.....	.....	114°·51	278°·79	54°·17	231°·16	206°·23	56°·23	119°·87	.....	116°·59
R_3	.....	0·031	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_3	.....	333°·85	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_4	0·005	0·024	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·025	.....
ϵ_4	35°·22	345°·78	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	320°·59	.....
R_6	0·005	0·047	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_6	257°·21	199°·45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_8	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_8	161°·87	215°·81	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·043$ $\epsilon = 93°·74$
„ fortnightly „	...	...	$R = 0·005$ $\epsilon = 107°·17$
Luni-solar „	...	...	$R = 0·024$ $\epsilon = 150°·08$
Solar annual „	...	...	$R = 0·099$ $\epsilon = 50°·68$
„ semi-annual „	...	...	$R = 0·098$ $\epsilon = 193°·94$

The value of the mean level of the sea (A_0) is 7·060 feet above the zero of the gauge. This is, with the exception of the value for 1872-73 (old gauge), the lowest value yet obtained at Kurrachee.

From an inspection of the values deduced at Kurrachee during the last 15 years, the mean level of the sea appears to follow a uniform curve, having a period of 10 years: its maximum occuring five years after its minimum value, and *vice versâ*.

The amplitude of the main lunar tide (R_2 of M) is 2·618 feet, which is the highest value yet obtained at Kurrachee. The amplitudes for the three preceding years are tolerably accordant *inter se*, and their average value is 2·544 feet.

With regard to the main solar tide, its amplitude agrees very closely with the preceding year's value, being 0·962 of a foot. The whole of the values of the amplitude of this tide at Kurrachee are very accordant.

The proportion of the main solar to the main lunar tide is, as might be expected from the foregoing, the lowest value yet obtained, being 0·367, or 10 per cent less than the theoretical value.

The lunar elliptic semi-diurnal tides are slightly different in their proportions to the main tide this year from the values in 1881-82.

The component (N) is 23 per cent of the main tide against 19 per cent, the theoretical; but this tide has always been found at Kurrachee from 3 to 7 per cent too great. The smaller component (L) agrees fairly well in its proportion to the main tide.

The smaller evectional semi-diurnal tide (λ) may be said to be absolutely *nil* for this year; theoretically this is perfectly insignificant, and such has almost always been found the case at Kurrachee. The larger component (ν) is for this year 5 per cent of the main tide; last year it was 8 per cent: theoretically it ought to be 4 per cent.

The variational semi-diurnal tide (μ) is fairly accordant with theory in its proportion to the main tide for the present year; as a rule this tide at Kurrachee has the proper proportion to the main tide.

The solar elliptic semi-diurnal tides have this year been evaluated, and may be said to be quite insignificant.

The luni-solar declinational semi-diurnal tide (R_4 of K) has a proportion of 0·075 to the main tide: theoretically it ought to be 0·126; last year it was also too small, while in 1880-81 it was 4 per cent too great, and in 1879-80 it agreed exactly with the theoretical value.

The luni-solar compound semi-diurnal tide (2SM) is, as has always been found at Kurrachee, perfectly insignificant in its proportion to the main tide.

With reference to the diurnal tides, the largest (R_1 of K) has a proportion of 0·469 to the main tide, and the remark on this tide, given in the discussion of the co-efficients for last year holds good for the present year, viz., that from 1874 to 1878 the proportions of this tide to the main tide agreed exactly with theory, and since the latter date it has steadily been decreasing. The next largest diurnal tide (R_1 of O) is only half as large in proportion to the main tide as it ought to be by theory; this tide too has steadily been decreasing since 1878. The solar diurnal declinational tide (R_1 of P) is 15 per cent of the main tide against 19 per cent, the theoretical value.

The remaining diurnal tides agree fairly well in their proportions to the main tide with last year's values.

With regard to the over-tides the lunar sexter-diurnal agrees very closely with previous values, and is about 2 per cent of the main tide, which although apparently a very small proportion, is nevertheless a very high value for an open coast station. The remaining over-tides are insignificant.

With regard to the long-period tides; the lunar monthly is only about one-third its proper value in proportion to the main tide. The lunar fortnightly is almost *nil*, while theoretically it ought to be 9 per cent of the main tide. The luni-solar fortnightly agrees well in its proportion to the main tide with the theoretical value.

The solar annual tide is again 4 per cent of the main tide, as was found in the two preceding years. Its time of maximum also agrees within one day with that obtained last year.

The semi-annual tide is also 4 per cent of the main tide, which it ought to be theoretically. Former values of this tide in proportion to the main tide, agree tolerably well with theory.

VALUES OF THE TIDAL CONSTANTS, KATHIWADAR, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Kathiwadar :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	13·872	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_1	0·134	0·103	0·067	1·533	0·456	0·163	0·141	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_1	200°·08	131°·13	346°·86	147°·59	340°·67	184°·28	345°·49	.....	.....	.....	.....	.....	...	...	.....	.....
R_2	1·207	3·024	.....	0·283	.....	.....	.....	0·063	0·769	0·044	0·153	0·297	...	...	.....	0·030
ϵ_2	80°·89	83°·42	.....	65°·12	.....	.....	.....	72°·00	31°·84	253°·23	13°·50	339°·55	...	...	.....	183°·63
R_3	.....	0·021	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_3	.....	149°·08	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_4	0·029	0·223	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·162	.....
ϵ_4	272°·78	174°·39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	213°·53	.....
R_6	0·013	0·147	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_6	41°·89	131°·88	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_8	0·002	0·008	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_8	253°·05	191°·20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....

Long-Period Tides.

Lunar monthly tide	$R = 0·055$	$\epsilon = 7°·56$
„ fortnightly „	$R = 0·023$	$\epsilon = 80°·47$
Luni-solar „ „	$R = 0·041$	$\epsilon = 154°·65$
Solar annual „ „	$R = 0·236$	$\epsilon = 133°·36$
„ semi-annual „	$R = 0·109$	$\epsilon = 155°·95$

The observations having been taken by the registration of the height of the tide on a graduated staff, and extending over only one year, the values deduced at this port can only be compared with those obtained at the two stations on either side, viz. Okha and Bombay.

The value of the mean level of the sea (A_0) is 13·872 feet above the zero of the gauge, or 10·668 feet below the bench mark on the bunder wall.

The value of the amplitude of the main lunar tide is 3·024 feet, which is 9 inches less than the value at Okha, and one foot less than that at Bombay.

The main solar tide (R_2 of S) is 1·207 feet, a value which agrees very well with what was obtained at Okha, but is 5 inches less than at Bombay. The proportion of the main solar to the main lunar tide is 40 per cent against 47 per cent, the theoretical value, and this is precisely the same proportion as we find at Bombay, while at Okha it is only 33 per cent.

The lunar elliptic semi-diurnal tides agree fairly well in proportion to the main tide, with the theoretical values. The larger component (N) being about 6 per cent too large; and here again this tide agrees well with the proportion obtained at Bombay in its relation to the main tide.

The smaller evectional tide (λ), although twice as large as it ought to be, is really insignificant, while the larger component (ν) agrees well with the theoretical proportion to the main tide, being 0·044 against 0·038, the proper value.

The variational tide (μ) is 4 times as great as it ought to be. At Bombay and Okha it is only twice as large as its theoretical value.

The solar elliptic semi-diurnal tides have not been computed, as two years' observations are required for this purpose.

The luni-solar declinational semi-diurnal tide (R_2 of K) is 0·094 of the main tide, against 0·126 the theoretical proportion; at Bombay this tide is 10 per cent, and at Okha 11 per cent of the main tide.

With reference to the diurnal tides, the chief one is 51 per cent of the main tide, while theory would give 58 per cent, thus it approaches much closer to the theoretical value at Kathiwadar than at Okha or Bombay. The next largest tide of this period, *i.e.*, the lunar declinational (R_1 of O) is only about half as large as it ought to be, being 22 per cent of the main tide, a value which corresponds to what was found at Okha, and is much nearer the theoretical value than what obtains at Bombay.

The solar declinational tide (R_1 of P) is 0·144 of the main tide, against 0·193 the theoretical value; while at Bombay and Okha it is only 0·100 of the main tide. The remaining four diurnal tides are each from 4 to 5 per cent of the main tide. With regard to the over-tides, the lunar quarter-diurnal tide is more than double as large in proportion to the main tide as the value obtained at Bombay and Okha, and this would seem to shew that the locality where the observations were taken, is separated from the open sea by a considerable space of shallow water.

The sexter-diurnal over-tide is also very large at Kathiwadar, being 5 per cent of the main tide, a value much higher than has been obtained at any open coast station, and closely resembles what is found at riverain ports and stations at the head of an estuary. The remaining over-tides are insignificant.

With regard to the long-period tides, the lunar monthly, the lunar fortnightly, and the luni-solar fortnightly, are all very small.

The solar annual tide is 8 per cent of the main tide, and its time of maximum occurs about the 3rd August. At Okha and Bombay this tide is about 5 per cent of the main tide, and its time of maximum appears to be about the 24th March at the former and the 15th March at the latter station, so that the values now obtained for this tide at Kathiwadar cannot be considered satisfactory.

The solar semi-annual tide is 4 per cent of the main tide, which agrees with theory, and at Bombay and Okha this has also been found to be the case.

VALUES OF THE TIDAL CONSTANTS, BOMBAY, 1882.

The following are the amplitudes and epochs deduced from the 1882 observations at Bombay:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	10·194	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_1	0·073	0·053	0·191	1·326	0·336	0·062	0·093	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_1	178°·80	318°·43	325°·00	127°·34	311°·07	161°·79	350°·79	.....	.....	.....	.....	.....	...	...	.....	.....
R_2	1·616	4·096	.....	0·536	.....	.....	.....	0·112	1·008	0·044	0·266	0·221	...	...	.....	0·034
ϵ_2	3°·79	325°·24	.....	335°·38	.....	.....	.....	113°·07	316°·44	95°·20	324°·07	314°·66	...	...	.....	95°·78
R_3	.....	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_3	.....	17°·87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_4	0·005	0·129	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·137	.....
ϵ_4	238°·13	324°·32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	23°·52	.....
R_5	0·002	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_5	182°·49	118°·76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_6	0·000	0·005	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_6	71°·57	29°·10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}091$ $\epsilon = 36°{\cdot}16$
„ fortnightly „	...	...	$R = 0{\cdot}043$ $\epsilon = 24°{\cdot}95$
Luni-solar „	„	...	... $R = 0{\cdot}023$ $\epsilon = 137°{\cdot}46$
Solar annual „	„	...	... $R = 0{\cdot}179$ $\epsilon = 355°{\cdot}41$
„ semi-annual	„	...	... $R = 0{\cdot}145$ $\epsilon = 218°{\cdot}18$

The value of (A_0), the mean level of the sea, is rather more than half inch lower than the value for 1881, but agrees very closely with the 1879 and 1880 values.

The amplitudes of the two main tides are, it may be said, precisely the same as the 1881 values, when it was remarked that the main lunar tide had the highest value yet obtained at Bombay, and the solar tide was, in comparison to the lunar, the least yet obtained; its proportion this year to the main lunar tide is 0 395 (same as last year), which is considerably less than the theoretical (0·465) proportion.

The smaller lunar elliptic tide (L) agrees with the theoretical proportion to the main tide, but the larger tide (N) is 5 per cent too great, and this is almost precisely what was found in the former observations at Bombay.

The smaller evectional tide (λ) is, as it should be, almost insignificant, but the larger tide (ν) is, for this year, about double its theoretical proportion, while for last year it was slightly too small.

The variational tide (μ) has a proportion to the main tide, of double the theoretical value, but this agrees very well with what was found to obtain from previous observations.

The luni-solar declinational tide (R_2 of K) is only 8 per cent of the main tide; while theory gives 13 per cent as the proportion: for 1877 and 1878 the proportions were slightly too large, while for the three following years they are slightly too small; thus the proportions have been steadily decreasing from 1877 up to the present year.

Of the diurnal tides, the largest, the luni-sloar (R_1 of K) is only 32 per cent of the main tide, instead of the theoretical proportion of 58 per cent; and the proportions have been steadily decreasing from 39 per cent in 1877 to the present value, which is the least yet obtained.

The next largest diurnal tide is the lunar declinational, which ought to be in proportion to the main lunar tide 0·415: for this year it is only 0·144, and this tide too appears to be following the same law as the main diurnal tide mentioned above. Of the remaining diurnal tides, they all seem to have about half their theoretical values, and agree well with the former values at Bombay.

Regarding the over-tides, they are all insignificant, with the exception of the lunar quarter-diurnal (about 3 per cent of the main tide) which agrees closely with its former values.

Regarding the long-period tides, the lunar monthly, although it has the largest value yet obtained in proportion to the main tide, is only one-half what theory would give. The luni-solar fortnightly is, as it should be by theory, almost insignificant, and this is what has always been found at Bombay. The lunar fortnightly is only 1 per cent of the main tide, while theory would give 9 per cent; but at Bombay it has never exceeded in its proportion to the main tide, 2 per cent.

The solar annual tide agrees almost precisely with the value obtained for 1880 and for 1881, but its time of maximum would appear to be 40 days later, or about 15th March instead of the begining of February; but this year's values confirm the statement made in last year's report concerning this tide.

The semi-annual tide is about 4 per cent of the main tide, which agrees with the theoretical value, and is not very different from last year's proportion; its epoch appears to be about seven days earlier than last year, viz. about 9th January and 9th July.

VALUES OF THE TIDAL CONSTANTS, KARWAR, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Karwar.

Short-Period Tides.

	S	M	O	K	P	J	Q	L	N	λ	ν	μ	R	T	MS	2SM
A_0	5·492	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....
R_1	0·035	0·063	0·447	0·948	0·274	0·060	0·083	.....	.....	.....	.....	.....	...	...	...	.....
ϵ_1	167°·47	237°·63	328°·99	126°·98	310°·05	120°·45	342°·96	.....	.....	.....	.....	.....	...	...	...	.....
R_2	0·625	1·780	.....	0·154	.....	.....	.....	0·039	0·406	0·021	0·048	0·033	...	...	...	0·009
ϵ_2	334°·73	298°·99	.....	314°·48	.....	.....	.....	141°·92	277°·75	86°·74	350°·63	281°·01	...	...	...	353·01
R_3	.....	0·012	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....
ϵ_3	.....	238°·10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....
R_4	0·011	0·063	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·029	.....
ϵ_4	91°·64	3°·80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	58°·04	.....
R_6	0·006	0·010	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....
ϵ_6	39°·14	282°·16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....
R_8	0·004	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....
ϵ_8	302°·91	208°·29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....

Long-Period Tides.

Lunar monthly	tide	... ...	$R = 0·135$	$\epsilon = 31°·69$
„ fortnightly	„	... ...	$R = 0·022$	$\epsilon = 15°·47$
Luni-solar	„	... ...	$R = 0·031$	$\epsilon = 28°·39$
Solar annual	„	... ...	$R = 0·373$	$\epsilon = 317°·09$
„ semi-annual	„	... ...	$R = 0·033$	$\epsilon = 225°·45$

The value of the mean level of the sea (A_0) is again slightly lower than was obtained in former years, being 5·492 feet above the zero of the gauge.

The main lunar tide has an amplitude (1·780) greater than was obtained in the former years, but it is not materially larger than the value in 1881-82.

The main solar tide (R_2 of S) is 0·625, an amplitude which agrees very closely with the mean of the four previous years; its proportion to the main tide, however, is 35 per cent instead of 47 per cent, the value which theory would assign.

Both of the lunar elliptic semi-diurnal tides agree precisely in their proportions to the main lunar tide with the values obtained last year; the proportion for the smaller (L) being slightly less, and that for the larger (N), slightly greater than the theoretical proportions.

With regard to the evectional tides, the smaller (λ) is slightly larger than the proportion theory would give; but as was the case last year, it is really insignificant at Karwar. The larger component (ν) is 0·027 of the main tide, while the theoretical value is 0·038.

The variational tide (μ) agrees fairly well with its theoretical value in its proportion to the main tide, and this has usually been found the case at Karwar.

The luni-solar declinational tide (R_2 of K) is about 9 per cent of the main tide, a value which corresponds with what was obtained in the two former years, but is somewhat less than the theoretical value 0·126.

With reference to the diurnal tides, the chief one (R_1 of K) is 0·533 of the main tide, while theory would give 0·584: in the two first years' observations the proportion obtained was slightly greater, while for the two following years the value agreed well with the theoretical proportion. The next largest diurnal tide (O) is only 25 per cent of the main tide; this is the lowest proportion yet obtained at Karwar, and is considerably less than the theoretical (42 per cent) value. The lunar diurnal tide (R_1 of M) and the lunar elliptic tide (R_1 of J) agree almost exactly with the theoretical proportions to the main tide. The solar elliptic tide (R_1 of Q) is about 5 per cent of the main lunar tide, a value which agrees fairly well with that obtained for last year, but is less than the theoretical proportion. With reference to the solar declinational tide, the proportion to the main tide is close on 16 per cent, which is what has always been found at Karwar, but is slightly less than the theoretical proportion, 0·193.

The over-tides at Karwar, with the exception of the quarter diurnal lunar (R_4 of M) are insignificant in their proportion to the main tide: the quarter-diurnal tide is 0·035 of the main tide, a proportion which, although undoubtedly large, agrees well with the values obtained in the four previous years.

Regarding the long period tides at Karwar, the lunar monthly is about double what it ought to be; while for the two previous years it had only about half its theoretical proportion to the main tide.

The lunar fornightly tide is only 1 per cent of the main tide for the present year: in previous observations the values obtained varied from 4 to 2 per cent: theory would assign 9 per cent as the proper value. The luni-solar fortnightly tide is 0·017 of the main tide; it ought to be 0·007 by theory.

With regard to the solar annual tide at Karwar, the amplitude now obtained agrees well with last year's value, and its epoch would appear to be about a fortnight later.

The solar semi-annual tide for 1882-83 is only about one-half what it ought to be by theory. Its times of maxima are almost precisely the same as were found for last year, viz. about the 14th of January and the 14th of July.

VALUES OF THE TIDAL CONSTANTS, BEYPORE, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Beypore.

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2 *SM*
A_0	5·412	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_1	0·073	0·043	0·310	0·631	0·177	0·057	0·072	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_1	185°·05	153°·55	357°·48	152°·50	323°·32	159°·51	342°·75	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_2	0·341	0·963	.....	0·060	.....	.....	.....	0·028	0·203	0·017	0·007	0·015	0·028	0·036	.....	0·004
ϵ_2	16°·61	327°·06	.....	335°·49	.....	.....	.....	160°·55	305°·12	191°·74	294°·52	326°·09	291°·61	79°·21	.....	244°·88
R_3	.....	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_3	.....	193°·16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_4	0·006	0·021	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·009	.....	.....
ϵ_4	144°·69	37°·12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	55°·31	.....	.....
R_5	0·006	0·005	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_5	226°·33	132°·17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_6	0·001	0·009	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_6	319°·40	154°·65	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Long-Period Tides.

Lunar monthly tide	$R = 0·154$	$\epsilon = 33°·01$
„ fortnightly „	$R = 0·098$	$\epsilon = 25°·32$
Luni-solar „ „	$R = 0·042$	$\epsilon = 198°·95$
Solar annual „	$R = 0·321$	$\epsilon = 328°·87$
„ semi-annual „	$R = 0·189$	$\epsilon = 193°·16$

The value of the mean level of the sea (A_0) from the 1881-82 observations is 5·412 feet above the zero of the gauge, which agrees precisely with the former years' value.

The main lunar tide (R_2 of M) has a larger amplitude (0·968) than has been observed in any of the three former years. Its epoch is almost identical with the value obtained in 1879-80, and only differs very slightly from the values obtained in the two other years for which observations have been taken.

The main solar tide has also been found for this year to have a greater amplitude than in any of the preceding years. The main diurnal tide (R_2 of K) has an amplitude almost precisely similar to that obtained for last year. The proportion between the two main tides (R_2 of S and R_2 of M) is 0·352, which, although slightly greater than was obtained from the two previous values, is nevertheless considerably in defect of the theoretical (0·465) proportion. The lunar elliptic semi-diurnal tides (L and N) agree well in their proportion to the main tide with the theoretical values.

The proportion of the smaller evectional tide (λ) to the main tide is about three times as great as it ought to be: theoretically this tide is insignificant. With regard to the larger component (ν) the proportion to the main tide is 10 per cent while theory would only give something less than 4 per cent. In 1878-79 the proportion obtained coincided precisely with the theoretical value, and in the two following years the proportion was not greatly in excess of what it ought to be.

The variational tide (μ) is not very different in its proportion to the main tide from the theoretical value.

With regard to the solar elliptic tides R and T, the former is about 3 per cent and the latter about 4 per cent of the main tide, against 2 per cent and 5 per cent as formerly obtained. The luni-solar declinational tide is again much smaller than it ought to be, viz. 0·062 of the main tide, instead of 0·126; and although this tide has always been found in proportion to the main tide to be too small at Beypore, yet for this year the value obtained is much less than that deduced in any of the former years.

Regarding the diurnal tides, the principal (R_1 of K) is 70 per cent of the main tide, which although considerably lower than was formerly obtained from any of the previous years' observations, is much greater than the theoretical (0·584) proportion. As was remarked last year, the proportion at Beypore is much greater than has been found at any port, except Aden.

The next largest diurnal tide (R_1 of O) is 32 per cent of the main tide, which is considerably less than the theoretical value; and except in 1878-79 (when the proportion obtained was precisely the theoretical) the value of this diurnal tide at Beypore has always been found too small. The whole of the remaining diurnal tides agree well with the theoretical values in their proportion to the main tide.

With reference to the over-tides, there are no remarkable features, except as was stated last year, the larger proportion of the quarter-diurnal tide to the main tide than usually obtains at open coast stations.

As regards the long-period tides, the proportion of the lunar monthly to the main tide is 16 per cent, against 5 per cent, the theoretical value: this tide has always been found to be two or three times as great as it ought to be at Beypore.

The lunar fortnightly tide, which last year was about one-fourth of its proper amplitude, theoretically has this year a proportion to the main tide slightly greater than it ought to have.

The luni-solar fortnightly tide, which ought to be theoretically insignificant, is 0·043 of the main tide, which does not differ materially from the proportions obtained in former years.

With regard to the solar annual tide, the proportion obtained this year (although less than for any former year) is 35 per cent of the main tide; its time of maximum appears to be about 16 days later than in any of the previous years, being about the 17th of February.

The solar semi-annual tide agrees fairly well, both as regards amplitude and epoch with the values obtained last year.

VALUES OF THE TIDAL CONSTANTS, PAUMBEN, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Paumben:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2 *SM*
A 0	2·705	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R 1	0·023	0·015	0·107	0·279	0·115	0·010	0·013	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ 1	165°·15	116°·33	327°·39	130°·33	319°·57	119°·58	2°·10	.....	.....	.....	.....	.....	.....	.....	.....	.....
R 2	0·369	0·572	.....	0·107	.....	.....	.....	0·021	0·063	0·014	0·027	0·011	0·019	0·017	.....›	0·008
ϵ 2	94°·19	46°·02	.....	77°·57	.....	.....	.....	220°·15	29°·24	351°·13	335°·53	141°·48	195°·28	159°·56	.....	290°·38
R 3	.....	0·017	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ 3	.....	174°·61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R 4	0·003	0·015	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·017	.....
ϵ 4	304°·16	183°·55	.....	.....	.....	.....	.....	0	0	.....	.....	.....	.....	.....	292°·63	.....
R 6	0·006	0·010	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ 6	179°·03	28°·58	.....	.....	.....	.....	.....	›.....	.....	.....	.....	.....	.....	.....	.....	.....
R 8	0·001	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ 8	133°·09	305°·29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Long-Period Tides.

Lunar monthly	tide	...	...	$R = 0{\cdot}046$ $\epsilon = 39°{\cdot}72$
„ fortnightly	„	...	...	$R = 0{\cdot}028$ $\epsilon = 320°{\cdot}44$
Luni-solar „	„	...	...	$R = 0{\cdot}007$ $\epsilon = 28°{\cdot}40$
Solar annual	„	...	...	$R = 0{\cdot}171$ $\epsilon = 304°{\cdot}03$
„ semi-annual	„	...	...	$R = 0{\cdot}129$ $\epsilon = 111°{\cdot}04$

The mean level of the sea (A_0) by this year's observations is 2·705 above the zero, which is almost precisely the same value as was obtained in 1879-80, and is only about two-thirds of an inch lower than the 1880-81 value, which was the highest value obtained at Paumben.

The values of the whole four years to which the observations extended, are very accordant, being 2·666, 2·707, 2·759, and 2·705, which would give the mean value from the whole of the observations 2·709 feet above the zero of the gauge.

The main lunar tide (R_2 of M) is 0·579 in amplitude, which agrees very closely with the 1878-79 and 1879-80 values, but differs sensibly (considering the small value of the tide at Paumben) from last year's value.

The main solar tide is also somewhat less in magnitude than was found from last year's observations, when it was remarked that the value obtained was precisely the same as for the two previous years.

The epoch is slightly different, being 94·2 against 90·1, 92·3, and 91·4, the values in the former years.

With regard to the lunar elliptic semi-diurnal tides, the smaller component (L) agrees fairly well with the theoretical value in proportion to the main tide, and this was the case last year and in 1878-79; only in one year (1879-80) has the value of this tide been very different at Paumben from the theoretical proportion to the main tide.

The larger component (N) is 14 per cent of the main tide, instead of 19 per cent as theory would give, but this value at Paumben agrees well with what was obtained in all three former years.

The smaller evectional tide (λ) is this year three times as great as it ought to be, but this tide, which should be most insignificant, has varied considerably at Pumben; the larger component (ν) does not differ much in its proportion to the main tide from the theoretical value, being 0·047 against 0·038. The two previous years' values were somewhat higher.

The variational tide (μ) also agrees pretty well in its proportion to the main tide with theory.

The proportion of the main solar tide to the main lunar tide at Paumben has always been abnormally high, and this year the proportion is much the same as formerly, viz. 0·622. At no other station in India, except Tuticorin, where observations were only taken for a limited period, has the theoretical proportion been exceeded.

The luni-solar declinational semi-diurnal tide (R_2 of K) is about 7 per cent greater in its proportion to the main tide than theory would assign; but this tide has always been found about 6 or 8 per cent too high at Paumben.

The solar elliptic semi-diurnal tides, R and T, are this year evaluated; and the proportion of the latter to the main tide is only slightly less than the theoretical value.

With regard to the diurnal tides, the chief one (R_1 of K) is 0·482 of the main tide, which is the least value yet obtained at Paumben; the theoretical proportion is 0·584, and from the first two years' observations the value deduced was only slightly less than theory, viz. about 0·535, but last year and this year the value is about ten per cent. too small.

The next largest diurnal tide, the lunar declinational (R_1 of O) is 0·185 against 0·415, the theoretical value; but this tide has always been found at Paumben about one-half its proper value in comparison to the main tide.

The value of the lunar elliptic tide (J_1) the solar declinational tide (P) and the lunar declinational tide (R_1 of M) in proportion to the main tide, all agree closely with what theory would give, while the solar elliptic Q is only one-third its proper value.

The over-tides at Paumben all agree very well with former values, the largest being the ter-diurnal lunar, which is 3 per cent, and the quarter-diurnal lunar which is 2 per cent of the main tide.

With reference to the long-period tides, the lunar monthly is about twice as great as it ought to be in proportion to the main tide. This tide has always been found high at Paumben.

The lunar fortnightly is, on the other hand, less in proportion to the main tide than theory would give; while in the three former years it agreed well with the theoretical value.

The luni-solar fortnightly tide is this year insignificant, as it ought to be, former values having been abnormally high.

The solar annual tide is still larger than last year; it is about 30 per cent of the main tide, which is the greatest proportion yet obtained at Paumben, its epoch although about 18 days later than was obtained last year, agrees well with the mean of the three former years, and in fact this tide, which is obviously meteorological, has its maximum fairly well established as occurring in the middle of January.

The semi-annual tide is this year 22 per cent of the main tide against 31 per cent of the two former years; its maxima occur about the 16th of May and November, *i.e.*, two or three days earlier than the dates obtained last year.

VALUES OF THE TIDAL CONSTANTS, NEGAPATAM, 1881-82.

The following are the amplitudes and epochs deduced from the 1881-82 observations at Negapatam.

Short-Period Tides.

	S	M	O	K	P	J	Q	L	N	λ	ν	μ	R	T	MS	2SM
A_0	1·996	.....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_1	0·018	0·005	0·055	0·211	0·063	0·006	0·006	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_1	116°·78	242°·64	210°·25	66°·91	232°·47	65°·84	63°·60	.....	.....	.....	.....	.....	...	...	.....	.....
R_2	0·271	0·726	.....	0·052	.....	.....	.....	0·017	0·167	0·025	0·049	0·019	...	...	.....	0·00
ϵ_2	233°·72	249°·40	.....	264°·63	.....	.....	.....	91°·74	240°·96	51°·95	226°·61	325°·08	...	...	.....	162°·59
R_3	.....	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_3	.....	70°·72	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_4	0·006	0·024	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·019	.....
ϵ_4	136°·56	72°·61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	91°·12	.....
R_5	0·000	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_5	135°·00	124°·86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_6	0·001	0·005	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_6	225°·00	239°·96	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....

Long-Period Tides.

Lunar monthly	tide	...	...	$R = 0·086$ $\epsilon = 345°·28$
„ fortnightly	„	...	...	$R = 0·051$ $\epsilon = 12°·15$
Luni-solar „	„	...	...	$R = 0·086$ $\epsilon = 3°·60$
Solar annual	„	...	...	$R = 0·543$ $\epsilon = 230°·61$
„ semi-annual	„	...	...	$R = 0·400$ $\epsilon = 125°·53$

The value of the mean level of the sea (A_0) is almost exactly 2 feet (1·996) above the zero of the gauge.

The amplitude of the main lunar tide (R_2 of M) is 0·726 feet, which represents fairly well a mean between the values obtained at Madras and Paumben, the two tidal stations on each side of Negapatam.

The amplitude of the main solar tide (R_2 of S) is 0·271 feet, which is only about three-fourths of the magnitude which would be expected in comparison to those at Madras and Paumben.

The proportion of the main solar to the main lunar tide is 0·373, which is 10 per cent less than the theoretical value; this is peculiar, because at Madras the proportion is 42 per cent and at Paumben (on the other side of Negapatam) the proportion is very much in excess of what theory would give, viz. about 63 per cent of the main tide.

The lunar elliptic tides agree fairly well with their theoretical values, the smaller component (L) being slightly less, and the larger component (N) being slighly greater, than the theoretical proportions to the main tide.

The smaller evectional tide (λ) is about five times as great as it ought to be, while the larger (ν) is nearly double in proportion to the main tide, the value which theory gives. The variational tide (μ) agrees with its theoretical value.

The luni-solar declinational semi-diurnal tide (R_2 of K) is 9 per cent of the main tide, the theoretical value being 13 per cent.

With regard to the diurnal tides, the values are all much smaller than the theoretical values. Commencing with the largest, the luni-solar diurnal tide (R_1 of K) which ought to be 58 per cent of the main tide, we find at Negapatam it is only 29 per cent. At Paumben this tide did not materially differ in its proportion to the main tide from the theoretical value, but at Madras it was only 26 per cent, and at Vizagapatam even less, viz. 22 per cent of the main tide. This diurnal tide seems to decrease regularly from Paumben as we proceed north along the east coast of India.

With regard to the next largest diurnal tide, the lunar declinational (R_1 of O), the proportion to the main tide at Negapatam is only 12 per cent, while theory would give 42 per cent. This tide would appear to follow the same law which has been noticed in the luni-solar diurnal tide.

The solar declinational tide (R_1 of P) is 11 per cent of the main tide; the theoretical proportion is over 19 per cent. The same remark regarding the decrease from south to north along the east coast of India appears to hold good for this tide.

The remaining diurnal tides at Negapatam are insignificant, except the solar diurnal, which is about 7 per cent of the main tide. The over-tides at Negapatam, with the exception of the lunar quarter-diurnal (which is over 3 per cent of the main tide), are insignificant.

With reference to the long-period tides, the lunar monthly is nearly three times as great as it ought to be, while at Madras the proportion to the main tide agrees well with theory, and at Paumben the proportion to the main tide is about twice as great as it ought to be.

The lunar monthly tide is 7 per cent of the main tide against 9 per cent, the theoretical value.

The solar fortnightly tide, which ought theoretically to be 1 per cent of the main tide, is 12 per cent at Negapatam. This is peculiar, because at none of the other stations on the east coast of India has the proportion to the main tide been more than 2 or 3 per cent. *But the main feature of the tide at Negapatam is the extraordinary high proportion of the solar annual and semi-annual to the main lunar tide, being actually 75 per cent and 55 per cent respectively, of the main tide.* At no other station, except Kidderpore, has this very large proportion been observed. It would appear to attain its maximum about the 10th November.

The solar semi-annual tide is also, in proportion to the main tide, by far the largest yet obtained at any port in India, its times of maximum would appear to be 25th May and 25th November, the latter date clearly shewing the tide to be meteorological in its origin.

VALUES OF THE TIDAL CONSTANTS, MADRAS, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Madras.

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2*SM*
A_0	2·179	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_1	0·012	0·008	0·692	0·277	0·103	0·019	0·003	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_1	98°·75	155°·31	244°·39	64°·07	260°·05	219°·73	323°·43	.....	.....	.....	.....	.....	...	...	.....	.....
R_2	0·440	1·072	.....	0·031	.....	.....	.....	0·012	0·245	0·036	0·074	0·031	...	...	.....	0·025
ϵ_2	276°·33	246°·29	.....	270°·38	.....	.....	.....	126°·47	240°·62	88°·01	315°·90	179°·94	...	...	.....	179°·63
R_3	.....	0·006	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_3	.....	64°·17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_4	0·001	0·005	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·004	.....
ϵ_4	217°·88	189°·06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	278°·30	.....
R_6	0·001	0·010	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_6	173°·91	145°·24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_8	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_8	230°·56	76°·03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....

Long-Period Tides

Lunar monthly tide ...	...	$R = 0·059$	$\epsilon = 68°·07$
„ fortnightly „ ...	...	$R = 0·045$	$\epsilon = 2°·67$
Luni-solar „ „ ...	...	$R = 0·021$	$\epsilon = 45°·85$
Solar annual „ ...	...	$R = 0·449$	$\epsilon = 211°·31$
„ semi-annual „ ...	...	$R = 0·257$	$\epsilon = 114°·65$

The mean level of the sea (2·179) is slightly lower than the value obtained from former years.

The main lunar tide (R_2 of M) is slightly greater in amplitude than the value for last year: the epoch does not differ much from that obtained in the two preceding years.

The main solar tide agrees almost exactly with the former values, both as to amplitude and epoch.

With regard to the lunar elliptic semi-diurnal tides, they are slightly larger in proportion to the main tide than theory would give, being 0·039 for L and 0·227 for N, while the theoretical proportions are 0·028 and 0·194 respectively. For the latter component (N) the proportion now found, agrees very closely with former proportions.

The evectional semi-diurnal tides (ν) and (λ) are both much larger than theory would give; the value of the smaller co-efficient (λ), however, agrees fairly well with the values obtained formerly; but the run of the values of (ν) for the present and former years is not satisfactory.

The variational tide (μ) agrees well with the theoretical proportion to the main tide: in former years it was always about double its theoretical magnitude.

The luni-solar semi-diurnal tide (R_2 of K) is much smaller in its proportion to the main tide than it ought to be: in 1880-81 this tide was found to agree fairly well with the theoretical value, and in 1881-82 its proportion to the main tide was 0·106 against 0·126 (the theoretical proportion), while for the present year it is only 0·076 of the main lunar tide.

With regard to the diurnal tides, the main lunar diurnal (R_1 of K) is less than half what it should be by theory, but agrees with former values; and the same remark applies to the solar declinational (P) and the lunar elliptic (J).

The lunar declinational (O) should theoretically be the second largest diurnal tide, and ought to have a proportion of nearly 42 per cent of the main lunar tide (R_2 of M): at Madras this tide has always been found to be only about 8 per cent of the main tide.

The lunar declinational (R_1 of M) and solar elliptic (Q), are for the 1882-83 observations insignificant, and this has always been the case at Madras.

The over-tides, both solar and lunar, are insignificant at Madras.

As regards the long-period tides, the lunar monthly is a little in excess of the theoretical proportion, while last year it agreed precisely with the value theory would assign.

The lunar fortnightly is, as formerly, one-half what it should be by theory, while the luni-solar fortnightly is three times as great as it ought to be, but still is much less than was found for last year.

Again, at Madras, the main features of the long-period tides are the large values of the solar-annual and semi-annual tides; the former is 42 per cent of the main tide, which is even much greater than the two previous values—36 per cent and 32 per cent. The semi-annual tide, which ought theoretically to be 4 per cent of the main tide, is, for Madras, from the 1882-83 observations 24 per cent, while in the previous year it was as high as 36 per cent.

Undoubtedly these two long-period tides are meteorological. The time of maximum of the solar-annual being about the 20th October, agrees pretty fairly with the times obtained in former years; and for the solar semi-annual, the times of maximum being 17th May and 17th November, are also very concordant with the dates obtained from previous observations.

Thus, as was remarked last year, the combined maximum effect of solar-annual and semi-annual tides would be felt about the middle of November, and at this time the high waters are certainly much higher than at any other time of the year.

The very large values of these two long-period tides along the whole of the east coast of India, would now seem to be an established fact.

VALUES OF THE TIDAL CONSTANTS, VIZAGAPATAM, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Vizagapatam:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	4·812	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_1	0·006	0·007	0·129	0·317	0·019	0·022	0·013	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_1	1°·49	332°·25	249°·60	67°·00	239°·35	59°·14	256°·06	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_2	0·041	1·470	.....	0·263	.....	.....	.....	0·009	0·316	0·025	0·139	0·035	0·039	0·050	.....	0·016
ϵ_2	288°·50	153°·20	.....	203°·43	.....	.....	.....	33°·62	259°·74	96°·41	280°·75	322°·71	340°·90	268°·35	.....	149°·51
R_3	.....	0·008	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_3	.....	11°·25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_4	0·006	0·019	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·015	.....
ϵ_4	29°·81	338°·87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	335°·00	.....
R_6	0·002	0·009	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_6	214°·7	29°·74	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_8	0·001	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_8	77°·91	126°·61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Long-Period Tides.

Lunar monthly tide	$R = 0{\cdot}077$	$\epsilon = 35°{\cdot}07$
„ fortnightly „	$R = 0{\cdot}022$	$\epsilon = 340°{\cdot}08$
Luni-solar „ „	$R = 0{\cdot}049$	$\epsilon = 103°{\cdot}71$
Solar annual „	$R = 0{\cdot}707$	$\epsilon = 174°{\cdot}73$
„ semi-annual „	$R = 0{\cdot}241$	$\epsilon = 100°{\cdot}78$

The value of the mean level of the sea (A_0) is 4·812 feet, a value almost precisely the same as obtained in 1881-82.

In the two previous years the value was from one to two inches higher.

The amplitude of the main lunar tide (R_2 of M) is 1·470 feet, which may be said to be exactly the same value as obtained last year, and is a mean between the two values in 1879-80 and 1880-81.

The amplitude of the main solar tide (R_2 of S) is 0·641 feet, which agrees well with the values obtained in the three previous years.

The proportion of the main solar to the main lunar tide is 0·436, which agrees well with the proportion previously obtained at Vizagapatam, and is 3 per cent less than the theoretical proportion.

The lunar elliptic semi-diurnal tides are both larger in their proportion to the main tide than theory would show. The smaller component (L) being about 5 per cent instead of 3 per cent and the larger componet (N) 22 per cent instead of 19 per cent of the main tide; but at Vizagapatam the latter has always been larger than its theoretical value, while the former, last year, was less in its proportion to the main tide, and in the two previous years it agreed fairly well with the theoretical proportion.

The smaller exectional tide is in proportion to the main tide about double what it should be, and this has always been found to be the case at Vizagapatam.

With regard to the larger component (ν) of this tide, the proportion to the main tide is 0·088, the theoretical value being 0·038; this tide last year was perfectly insignificant, while in 1880-81 the value obtained was precisely the theoretical value.

The variational tide (μ) has exactly the same proportion to the main tide as theory would assign. Former values of this tide at Vizagapatam were slightly too small.

The solar elliptic semi-diurnal tides have this year been computed. The component (R) is 0·027 and the component (T) 0·054 of the main tide; the latter should be only half as large according to theory.

The luni-solar declinational semi-diurnal tide (R_2 of K) is 0·179 of the main tide, which is about 6 per cent too large; the two former values of this tide at Vizagapatam were slightly too small, while in 1879-80 the proportion obtained agreed well with theory.

With regard to the diurnal tides at Vizagapatam, the chief diurnal tide (R_1 of K) is 22 per cent of the main tide against 58 per cent, the theoretical value; but the diurnal tides have been discussed in the remarks on the Negapatam tides, and it need only be mentioned with regard to the remaining tides of this period at Vizagapatam, that they are all very much smaller than theory would give.

The over-tides at Vizagapatam deduced from the 1882-83 observations call for no special mention.

With regard to the long-period tides, the lunar monthly agrees fairly well with the theoretical proportion to the main tide, and the lunar fortnightly has only about one-fifth its proper value, while the luni-solar fortnightly is about five times as great as it ought to be.

These proportions are not very different from what has usually been observed at Vizagapatam. *But, as has always been observed at this port, the distinguishing feature is the very large proportion of the solar annual tide to the main tide.*

At Vizagapatam this tide has ranged from 40 to 57 per cent of the main tide (this year it is 48 per cent), and except the extraordinarily high proportions which have been observed at Kidderpore, Negapatam, and Moulmein, such a large value has not been obtained at any other port in India; and two of the ports above mentioned are riverain ports, which are not strictly comparable with an open coast station like Vizagapatam.

The solar semi-annual tide for this year at Vizagapatam is only about one half the magnitude observed last year, but still it is four times greater than the value which theory would give.

VALUES OF THE TIDAL CONSTANTS, FALSE POINT, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at False Point.

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	7·597	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_1	0·021	0·013	0·160	0·381	0·157	0·027	0·014	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_1	4°·752	90°·52	253°·05	68°·65	249°·51	37°·29	219°·91	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_2	1·033	2·306	.....	0·203	.....	.....	.....	0·040	0·492	0·053	0·123	0·084	0·034	0·017	.....	0·014
ϵ_2	304°·28	269°·44	.....	232°·33	.....	.....	.....	48°·30	265°·46	261°·30	238°·97	276°·29	316°·14	225°·23	.....	178°·76
R_3	.....	0·017	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_3	.....	24°·39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_4	0·003	0·013	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·015	.....
ϵ_4	326°·24	235°·57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	273°·21	.....
R_5	0·003	0·012	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_5	185°·04	41°·70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_6	0·003	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_6	261°·12	255°·76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·078$ $\epsilon = 57°·50$
„ fortnightly „	...	...	$R = 0·057$ $\epsilon = 11°·88$
Luni-solar „ „	...	...	$R = 0·060$ $\epsilon = 74°·99$
Solar annual „	...	...	$R = 0·840$ $\epsilon = 165°·73$
„ semi-annual „	...	...	$R = 0·210$ $\epsilon = 149°·02$

The value of the mean level of the sea (A_0) is 7·597 against 7·552 in 1881-82, and the zero of the gauge has not altered with reference to the bench mark in the smallest degree during the year under review.

The amplitude of the main lunar tide is 2·306 feet, which agrees very well with the value obtained last year, viz. 2·274.

The main solar tide (R_2 of S) has an amplitude almost precisely the same as was obtained last year, viz. a trifle over a foot. From the above it is evident that the proportion between the two main tides now obtained, agrees well with last year's value, when it was remarked as being a little less than the theoretical proportion, and nearly the same as the value determined at Vizagapatam.

The smaller lunar elliptic tide is this year about half as large as it ought to be: last year it agreed with the theoretical value. The larger component of this tide agrees exactly in its proportion to the main tide with the value found last year, which, again, agreed well with the theoretical proportion to the main tide.

With regard to the evectional tide (λ) the proportion to the main tide is five times as much as it should be; last year it was also too large. This tide theoretically is quite insignificant.

The larger component (*ν*) is also greater in its proportion to the main tide than the value which theory would give, but not so much so as was observed last year.

The variational tide (*μ*) agrees well with the theoretical value, as was the case last year.

The solar elliptic tides have this year been evaluated: they are both very small.

The Luni-solar declinational semi-diurnal tide (R_2 of K) is 9 per cent of the main tide: last year it was 14 per cent; theoretically it ought to be 13 per cent.

With regard to the diurnal tides, they are all much smaller in proportion to the main tide than the values which theory would give, *and in fact the diurnal tides in the Bay of Bengal have all smaller proportions to the main lunar tide than is observed at the ports on the west coast of India.* The chief tide of this period (R_1 of K) is only 17 per cent of the main lunar tide, instead of 58 per cent, while next largest (the lunar declinational) is 7 per cent of the main tide, instead of 42 per cent, the theoretical proportion.

The solar declinational tide (R_1 of P) is also 7 per cent of the main tide, while theory would give 19 per cent. The remaining diurnal tides at False Point are quite insignificant.

With the exception of the lunar quarter-diurnal, the over-tides at False Point are very small, and call for no special remark. The lunar quarter-diurnal is 0·019 of the main tide, which agrees well with the value obtained in 1881-82.

With reference to the long period tides, the lunar monthly, although larger than last year, is still somewhat less than it ought to be by theory: the lunar fortnightly tide is only about one-quarter its proper value, and this proportion to the main tide is exactly what was obtained last year.

The luni-solar fortnightly tide, which, theoretically, is quite insignificant, viz. 0·007 of the main tide is for this year at False Point 0·026: last year it was also three times as large as it ought to be.

The solar annual tide is for this year 36 per cent of the main tide, which, with the exception of the value at Paumben, is the smallest proportion to the main tide yet obtained at any of the stations on the east coast of India. Its time of maximum is about the 5th September, which is only about nine days earlier than the date obtained at Vizagapatam from the same year's observations.

The solar semi-annual tide at False Point is for this year 9 per cent of the main tide, or rather more than double what it should be: last year it was four times too large. Its epoch, or time of maximum, agrees with the last year's value within four days.

VALUES OF THE TIDAL CONSTANTS, KIDDERPORE, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Kidderpore.

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	10·686	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_1	0·033	0·033	0·190	0·364	0·142	0·011	0·053	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_1	189°·51	289°·36	299°·70	135°·72	322°·52	16°·19	299°·74	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_2	1·508	3·742	.....	0·256	.....	.....	.....	0·137	0·612	0·077	0·153	0·272	0·707	0·147	.....	0·068
ϵ_2	100°·52	55°·93	.....	63°·8	.....	.....	.....	241°·14	44°·52	262°·52	347°·26	156°·56	178°·01	186°·19	.....	29°·37
R_3	.....	0·019	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_3	.....	323°·16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_4	0·034	0·752	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·637	.....
ϵ_4	119°·63	32°·03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	75°·53	.....
R_6	0·004	0·171	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_6	331°·70	309°·75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_8	0·002	0·020	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_8	323°·28	256°·45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Long-Period Tides.

Lunar monthly tide	... ...	$R = 0·185$	$\epsilon = 340°·65$
„ fortnightly „	... ...	$R = 0·234$	$\epsilon = 13°·94$
Luni-solar „	„	$R = 0·941$	$\epsilon = 44°·65$
Solar-annual	„	$R = 2·670$	$\epsilon = 157°·22$
„ semi-annual	„	$R = 0·708$	$\epsilon = 333°·63$

The mean level of the river from these observations was found to be 10·686 feet above the sill of the Kidderpore Dock. The value given for last year, 10·739, was incorrect, it should have been 10·773, so that the value for 1882-83 is about one inch lower than was found from the previous year's observations.

The amplitude of the main lunar tide is 3·742 feet, which is slightly larger than was obtained last year; and this remark applies also to the main solar tide, which for 1882-83 is 1·508 feet against 1·427 feet, as obtained in 1881-82. Thus, the proportion between the main tide is not materially different from that obtained last year.

With regard to the lunar elliptic tides, the smaller component (L) is in proportion to the main tide slightly too large, while the reverse is the case with regard to the larger component (N).

The smaller evectional tide (λ), which ought theoretically to be insignificant, is over 2 per cent of the main tide; the larger component of this tide (ν) agrees very well in its proportion to the main tide with the theoretical value.

The variational tide (μ) is three times too great according to its theoretical proportion to the main tide.

The solar elliptic semi-diurnal tides are 5 and 4 per cent respectively of the main tide.

The luni-solar declinational tide is 0·098 of the main tide, instead of 0·126, the value which theory would give : for last year the value obtained was very nearly the theoretical one.

The luni-solar compound semi-diurnal tide agrees almost exactly with the proportion obtained last year, while at Dublat this tide for 1882-83 was only about one-half the amplitude obtained from the 1881-82 observations.

But the *principal feature of the Hooghly tides*, as compared to those at open coast stations in India, appears to be *the extreme smallness of the diurnal tides as compared to the main lunar tides.* Thus, for the chief diurnal tide (R_1 of K) the proportion is only 10 per cent against the theoretical 58 per cent, and for the next largest (R_1 of O) it is only 5 per cent of the main lunar tide, while theory would give 42 per cent. The solar declination tide (R_1 of P) is 0·038 of the main tide, while the theoretical value is 0·193. The remaining diurnal tides at Kidderpore are quite insignificant.

With reference to the over-tides, the lunar quarter diurnal is, as might be expected, of considerable importance, being 20 per cent of the main tide, a value agreeing well with that obtained last year. The remaining lunar over-tides R_6 and R_2 are 0·046 and 0·024 of the main tide, which values are almost precisely the same as the 1881-82 values.

Hitherto it has been usual to compare the solar over-tides with the main solar tide, but it is obviously preferable to have one standard of comparison for all the tides, viz. the main lunar tide, which is assumed to be unity in computing the proportions ; thus, the solar quarter-diurnal tide is 0·022 of the main tide, while the other solar over-tides are quite insignificant. Regarding the long-period tides, their proportions to the main tide are very marked ; thus, the solar annual is 0·714 of the main tide, which is not very much less than the value obtained for last year, when it was remarked as the largest ever yet found at any port in India. It is remarkable that its epoch is precisely the same as was found for last year, viz. about the 28th of August, thus verifying the supposition that this tide is purely meteorological and due to the freshets in the Hooghly.

The solar semi-annual is this year 19 per cent of the main tide, which though somewhat less than the proportion obtained for last year, is five times as great as the theoretical value, and would appear to shew that this tide is also meteorological in its origin. One of the principal features of the long-period tides at Kidderpore is the very large magnitude of the luni-solar fortnightly tide, which though theoretically insignificant, is actually 25 per cent of the main tide ; and this proportion very closely coincides with all the previous values determined at Kidderpore.

The lunar monthly tide agrees very closely in its proportion to the main tide, while formerly the proportion obtained was much too large.

The lunar fortnightly is the only one of the long-period tides at Kidderpore which is less in proportion to the main tide than theory would shew, being 0·063 against 0·086 of the main lunar tide.

VALUES OF THE TIDAL CONSTANTS, DIAMOND HARBOUR, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Diamond Harbour :—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	T	*MS*	*2SM*
A_0	9·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_1	0·054	0·038	0·207	0·102	0·176	0·050	0·052	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_1	147°·38	190°·46	265°·02	96°·10	251°·52	58°·22	259°·60	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_2	2·253	0·291	.....	0·515	.....	.....	.....	0·275	0·035	0·039	0·190	0·318	0·216	0·078	.....	0·054
ϵ_2	52°·14	341°·37	.....	11°·74	.....	.....	.....	164°·26	333°·65	114°·44	282°·41	86°·57	110°·52	134°·33	.....	291°·48
R_3	.....	0·029	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_3	.....	22°·98	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_4	0·122	0·763	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·718	.....
ϵ_4	343°·01	241°·98	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	281°·98	.....
R_6	0·033	0·358	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_6	284°·53	90°·91	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_8	0·004	0·063	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_8	42°·56	336°·50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Long-Period Tides.

Lunar monthly	tide	...	... $R = 0.061$	$\epsilon = 351°.22$
,, fortnightly	,,	...	... $R = 0.113$	$\epsilon = 19°.91$
Luni-solar ,,	,,	...	... $R = 0.512$	$\epsilon = 41°.94$
Solar annual	,,	...	... $R = 1.189$	$\epsilon = 146°.81$
,, semi-annual	,,	...	... $R = 0.109$	$\epsilon = 76°.79$

The value of mean level of the river (A_0) is 9·011 feet against 8·976 in 1881-82.

The level of the river at Kidderpore for the same year is 10·686 feet above the sill of the dock, which is rather lower than in the preceding year (10·773) whilst at Dublat the value for 1882-83 is 14·499 against 14·394 in 1881-82; thus the mean level at Diamond Harbour is in accordance with that at Dublat.

The amplitude of the main lunar tide (R_2 of M) is 5·295 feet, which is only about three-fourths of an inch greater than the value obtained last year.

The main solar tide (R_2 of S) is also greater in amplitude than the value for 1881-82 by rather more than three-fourth of an inch.

The proportion of the main solar tide to the main lunar tide is 0·432, which is fairly accordant with the proportion obtained from the last year's observations, and is not materially less than the theoretical value (0·465).

With regard to the lunar elliptic semi-diurnal tides, the smaller component (L) has a proportion to the main tide 0·052 against 0·028 (the theoretical value), whilst in 1881-82 the proportion obtained agreed fairly well with what theory would give. The larger component (N), which also last year agreed very closely in its proportion to the main tide with the theoretical value, is slightly too small from the present year's observations.

Both the evectional tides agree closely in their proportions to the main tide with the values which theory would assign, while for last year the larger component (ν), was about twice as great as it ought to be, and the smaller component (λ), which theoretically ought to be perfectly insignificant, was, in 1881-82, over 3 per cent of the main tide.

With reference to the variational tide (μ) the proportion to the main tide is nearly three times as great as it ought to be; but this is in accordance with the values obtained in former years.

The solar elliptic semi-diurnal tides have been computed from the present year's observations combined with those for 1881-82, and the proportions obtained for the component R is 0·041 of the main tide, while for the other component (T) the value is 0·015. Theoretically this latter tide ought to have a proportion to the main lunar tide of double the value now obtained, and from the observations from 1874 to 1878, the values of this tide were generally more than double the theoretical proportion.

With regard to the luni-solar declinational semi-diurnal tide (R_2 of K) the proportion to the main tide is 0·103, while theory would give 0·126: for last year the proportion agreed well with the theoretical value; and in former years it was as a rule 4 per cent higher.

As was remarked last year, the diurnal tides at Diamond Harbour are all exceedingly small. The chief one (R_1 of K), which theoretically ought to be over 58 per cent of the main tide, is, from the present year's observations, barely 9 per cent.

The lunar declinational tide (R_1 of O) is only 4 per cent of the main tide, a value which agrees well with what has always been observed at diamond Harbour; but is very different from the theoretical proportion, 42 per cent.

The remaining diurnal tides are all insignificant at Diamond Harbour, while theoretically the solar declinational and lunar elliptic ought to have proportions to the main tide of nearly 20 and 8 per cent respectively.

With regard to the over-tides, the lunar quarter-diurnal is 15 per cent of the main tide, which is precisely the same as was obtained last year; and agrees well with the values deduced from the previous observations.

The lunar sexter-diurnal (R_6 of M) is again 3 per cent of the main tide at Kidderpore; this tide has even a larger proportion.

The solar quarter-diurnal has this year been compared with the main lunar tide instead of the main solar tide as formerly; its proportion is 0·023, which agrees well with the proportion obtained in former years when reduced to their values in comparision to the main lunar tide.

With regard to the long period tides, the lunar monthly and lunar fortnightly are much smaller in their proportion to the main tide than theory would give; the former is for this year insignificant.

The luni-solar fortnightly tide is again very large in its proportion to the main tide, viz. 10 per cent, while the theoretical proportion is barely 1 per cent; but this value is quite consistent with those formerly obtained at Diamond Harbour.

The solar-annual tide is 23 per cent of the main tide, which is slightly greater than the value in 1881-82; but agrees exactly with the mean of the values obtained from 1874 to 1878.

Its epoch, or time of maximum appears to be about one week later than last year, or about the 17th August.

With regard to the solar semi-annual tide, the proportion obtained from the present year's observations is about 2 per cent of the main tide, which is half the theoretical proportion: at Dublat, for this year, the proportion is exactly the same as the theoretical, while at Kidderpore this tide has always had an abnormally high value, ranging from 20 to 30 per cent of the main tide.

VALUES OF THE TIDAL CONSTANTS, DUBLAT, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Dublat:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	2*SM*
A_0	14·499	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....	.....
R_1	0·030	0·013	0·177	0·457	0·151	0·015	0·007	.....	.....	.....	.....	...	...	...	.....	.....
ϵ_1	120°·91	183°·27	253°·29	72°·66	260°·64	14°·99	250°·66	.....	.....	.....	.....	...	...	...	.....	.....
R_2	2·163	4·704	.....	0·521	.....	.....	.....	0·126	0·572	0·142	0·197	0·116	0·219	0·137	.....	0·047
ϵ_2	336°·29	288°·00	.....	310°·67	.....	.....	.....	112°·81	284°·79	110°·84	235°·55	15°·67	29°·66	18°·51	.....	228°·58
R_3	.....	0·014	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....	.....
ϵ_3	.....	132°·45	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....	.....
R_4	0·011	0·003	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	0·000	.....
ϵ_4	219°·54	241°·49	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	132°·24	.....
R_6	0·003	0·024	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....	.....
ϵ_6	75°·23	230°·84	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....	.....
R_8	0·007	0·010	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....	.....
ϵ_8	110°·55	266°·34	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	...	.....	.....

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}038$ $\epsilon = 125°{\cdot}40$
„ fortnightly „	...	...	$R = 0{\cdot}031$ $\epsilon = 49°{\cdot}56$
Luni-solar „	„	...	...	$R = 0{\cdot}079$ $\epsilon = 76°{\cdot}66$
Solar annual „	...	...	$R = 1{\cdot}003$ $\epsilon = 154°{\cdot}05$
„ semi-annual „	...	...	$R = 0{\cdot}182$ $\epsilon = 109°{\cdot}69$

The mean level of the sea was stated last year (1881-82) as being 14·394 feet above the zero of the gauge, which is correct, but the statement 8·580 feet below bench mark A is incorrect.

The gauge when first started appeared to have its zero 29·944 feet below the bed-plate, and this was accepted as the working zero of the instrument, subsequently it was found from the determinations of the zero in June 1882 that the value of the zero was 30·202 feet below the bed-plate. By careful leveling it was seen that no settlement had taken place in the observatory, and the only conclusion that can be made is that a kink had formed in the float-band when the work was started, and shortly afterwards this disappeared by the working of the instrument, thus the presumption is that the zero has been 30·202 below the bed-plate within a very short time after the observations were commenced. On this assumption the value of the mean level of the sea from the 1881-82 observations is 8·833 feet below bench mark A.

From the 1882-83 observations the value of the mean level of the sea is 14·499 feet above the zero of the gauge, or 8·728 feet below bench mark A, or 0·105 feet higher than was observed last year.

The amplitude of the main lunar tide (R_2 of M) agrees very well with the value obtained last year, being 4·704 feet against 4·679 in 1881-82.

The main solar tide is also greater in amplitude than was observed last year by 0·11 feet.

The proportion of the main solar to the main lunar tide agrees very well with the theoretical value; but last year it was remarked as being rather less than it ought to be.

With regard to the lunar elliptic tides, the smaller component (L) agrees exactly with its theoretical value: last year it was also very accordant with theory. The larger component (N) this year also agrees very closely in its proportion to the main tide with the theoretical value, while last year it was slightly too large.

The smaller evectional tide (λ) is this year only half as large in proportion to the main tide as it was last year, but is still four times greater than it ought to be.

The other component (ν) agrees well with the theoretical value.

The variational tide (μ) also agrees exactly with the theoretical value: last year it was twice as large.

The solar elliptic semi-diurnal tides are 0·047 (for R) and 0·029 (for T) of the main tide, the latter value being almost precisely what theory would give.

The luni-solar declinational semi-diurnal tide (R_2 of K) is precisely the same in proportion to the main tide as was observed last year, and is only slightly less than the theoretical proportion.

As regards the diurnal tides, they are all very much smaller than they ought to be theoretically; but it has been remarked formerly *that the diurnal tides in the Bay of Bengal decrease from south to north until, as at Dublat, they almost disappear.* Thus the chief diurnal tide (R_1 of K) has only a value of 10 per cent of the main tide, instead of 58 per cent as it ought to have theoretically, while the next two largest tides of this period (R_1 of O) and (R_1 of P) are only 4 and 3 per cent respectively of the main tide, while theory gives 42 and 19 per cent as the values. But the values obtained this year at Dublat are all very accordant with what was obtained in 1881-82.

The over-tides are all very small, and agree well with the values obtained last year; the largest of them, the quarter-diurnal lunar tide being again 2 per cent of the main tide.

With regard to the long-period tides, the lunar monthly, lunar fortnightly, and luni-solar fortnightly are all very small, and agree well with last year's values. The last mentioned tide ought to be insignificant, but the two former tides ought to have values of 5 and 9 per cent respectively of the main tide: at Dublat they appear to be barely 1 per cent.

The solar annual tide is this year 0·213 of the main tide against 0·170 for 1881-82. Its time of maximum agrees well with what was observed last year, being about the 24th August.

The solar semi-annual tide is 4 per cent of the main tide, which is the theoretical values: last year it also agreed well with the value theory would give.

VALUES OF THE TIDAL CONSTANTS, RANGOON, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Rangoon:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	14·953	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	...
R_1	0·697	0·023	0·272	0·615	0·166	0·017	0·025	.....	.....	.....	.....	.....	...	...	.....	...
ϵ_1	128°·78	251°·76	306°·23	116°·31	323°·08	16°·03	333°·67	.....	.....	.....	.....	.....	...	...	.....	...
R_2	2·025	5·697	.....	0·510	.....	.....	.....	0·413	0·936	0·135	0·188	0·560	...	...	.....	0·156
ϵ_2	171°·20	129°·36	.....	150°·88	.....	.....	.....	338°·07	113°·61	330°·24	128°·66	281°·45	...	..	.....	62°·25
R_3	.....	0·039	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	...
ϵ_3	.....	139°·49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	...
R_4	0·079	0·457	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·402	...
ϵ_4	258°·12	164°·34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	266°·26	...
R_6	0·011	0·251	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	...
ϵ_6	62°·97	81°·49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	...
R_8	0·005	0·069	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	...
ϵ_8	122°·47	85°·75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	...

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0·196$ $\epsilon = 38°·79$
„ fortnightly „	...	...	$R = 0·187$ $\epsilon = 17°·21$
Luni-solar „ „	...	...	$R = 0·601$ $\epsilon = 50°·83$
Solar annual „	...	...	$R = 1·444$ $\epsilon = 152°·48$
„ semi-annual „	...	...	$R = 0·174$ $\epsilon = 3°·33$

The mean level of the river (A_0) is 0·027 feet lower than last year, which, again, was 0·094 feet lower than in 1880-81, being 14·953 feet above the zero of the gauge.

The amplitude of the main lunar tide is slightly greater than in either of the preceding years, being 4·697 feet. Its epoch agrees very well with the values obtained in the two previous years.

The main solar tide is also greater than was observed in 1880-81 and 1881-82.

The proportion of the main solar to the main lunar tide is 0·355, which is 11 per cent less than the theoretical value, but in both the former years' observations the values were also considerably in defect of the theoretical proportion, and this seems to be the case at all riverain stations.

The smaller elliptic semi-diurnal tide (L) is two and a half times as large as it ought to be, which agrees with the 1880-81 value, and is not much larger than the value obtained in 1881-82.

The larger component (N) is slightly less in proportion to the main tide than it ought to be theoretically; this has also been observed in the values obtained from the two previous years' observations.

With regard to the evectional tides, the larger component (ν) agrees very well this year with the theoretical value; in the two former years it was two or three times too large: the smaller component (λ), which theoretically is perfectly insignificant, appears to be four or five times as large as it ought to be at Rangoon. The values of the variational tide (μ) for all three years' observations at Rangoon agree very well *inter se*, and are four times as great as they ought to be.

The solar elliptic semi-diurnal tides have not been evaluated this year.

The luni-solar declinational semi-diurnal tide (R_2 of K) is 9 per cent of the main tide, against 10 per cent in the two previous years; theoretically it ought to be 13 per cent.

With regard to the diurnal tides; they are all, as might be expected, exceedingly small; the values obtained this year are precisely in accordance with those obtained in the two previous years, and closely resemble the values at Kidderpore.

The lunar over-tides at Rangoon are all very large: the values now obtained agree very closely with those of the two previous years, and are, for the quarter-diurnal and sexter-diurnal, 8 and 4 per cent of the main tide respectively.

The only solar over-tide of any consequence is the quarter-diurnal, which, this year, is only 0·014 of the main tide, while in the two former years it was 4 per cent of that tide.

With regard to the long period tides, the lunar monthly, the lunar fortnightly, and luni-solar fortnightly, all agree fairly well with previous values; the two former are respectively, 1 and 5 per cent less than they ought to be. The luni-solar fortnightly, which theoretically is inappreciable, *has a value at Rangoon of about* 10 *per cent of the main tide.* At Moulmein this tide is *actually* 30 *per cent* and at Kidderpore 24 *per cent* of the main tide. Thus its existence as a significant factor seems to be clearly established at riverain stations.

The solar annual tide is 25 per cent of the main tide, a value which agrees well with what was obtained last year; and its time of maximum also agrees well this year with the 1881·82 value, being only one day earlier, and occurring on the 23rd August.

The solar semi annual tide is insignificant at Rangoon, while at Moulmein and Kidderpore it is about 16 and 25 per cent respectively, of the main tide.

VALUES OF THE TIDAL CONSTANTS, MOULMEIN, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Moulmein:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	*2SM*
A_0	8·655	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_1	0·090	0·006	0·236	0·388	0·144	0·008	0·035	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_1	147°·70	270°·13	329°·84	123°·84	326°·84	300°·13	332°·70	.....	.....	.....	.....	.....	...	...	.....	.....
R_2	1·343	3·344	.....	0·267	.....	.....	.....	0·139	0·645	0·121	0·173	0·331	...	...	.....	0·112
ϵ_2	150°·01	113°·31	.....	147°·19	.....	.....	.....	309°·33	100°·44	340°·34	56°·44	276°·29	...	...	.....	39°·11
R_3	.....	0·021	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_3	.....	136°·33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_4	0·065	0·335	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	0·709	.....
ϵ_4	231°·29	170°·78	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	212°·79	.....
R_5	0·004	0·102	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_5	185°·32	196°·98	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_6	0·002	0·045	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_6	218°·29	127°·30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....

Long-Period Tides.

Lunar monthly tide	...	...	$R = 0{\cdot}247$	$\epsilon = 21°{\cdot}38$
„ fortnightly „	...	...	$R = 0{\cdot}270$	$\epsilon = 19°{\cdot}04$
Luni-solar „	„	...	...	$R = 1{\cdot}173$ $\epsilon = 47°{\cdot}36$
Solar annual	„	...	...	$R = 2{\cdot}453$ $\epsilon = 148°{\cdot}89$
„ semi-annual	„	...	...	$R = 0{\cdot}593$ $\epsilon = 295°{\cdot}13$

The value of the mean level of the river may be said to be exactly the same as that obtained last year, viz. 8·658 feet above the zero of the gauge.

The amplitude of the main lunar tide (R_e of M) is 3·844 feet, a value which is a fairly good mean between the 1880-81 and 1881-82 values.

The main solar tide this year has precisely the same amplitude as was obtained last year viz. 1·343 feet. From what has been said above, the proportion between the main solar and main lunar tides obtained from this year's observations, agrees well with the two former years' values, and is about 10 per cent less than the theoretical proportion.

The lunar elliptic semi-diurnal tides are 0·050 (for L) and 0·168 (for N), of the main tide, against 0·028 and 0·194, the theoretical values.

The smaller evectional tide (λ) is four times as great as it ought to be: from the two former years' observations at Moulmein the value obtained was even greater.

The larger component (ν) this year agrees fairly well with the theoretical proportion to the main tide, while formerly it has been observed to be twice as large as the value which theory would assign.

The values obtained for all three years at Moulmein for the variational tide (μ), are very consistent, but are more than three times as large as they ought to be.

The luni-solar declinational semi-diurnal tide (R_e of K) is 7 per cent of the main tide, which is exactly what was found last year. In 1880-81 it was 11 per cent of the main tide; theoretically it ought to be 13 per cent.

With regard to the diurnal tides, the same remarks apply at Moulmein as at Rangoon and Kidderpore, they are all much smaller than they ought to be in comparison to the main tide. The three largest having proportions to the main tide of 10, 6, and 4 per cent, instead of 58, 42, and 19 per cent respectively.

But the values now obtained are quite in accordance with those of the two previous years.

The over-tides at Moulmein are large; the lunar quarter-diurnal being actually 24 per cent of the main tide. The values now obtained, however, are very accordant with those of the two previous years. At Rangoon the lunar quarter-diurnal is 8 per cent of the main tide, at Diamond Harbour it is about 15 per cent, and at Kidderpore about 20 per cent of the main tide: so that of all the riverain stations Moulmein has much the largest value for this over-tide.

The solar quarter-diurnal is 2 per cent of the main tide, a value which is precisely the same as obtains at Kidderpore, Diamond Harbour, and Rangoon from this year's observations.

With reference to the long-period tides, the lunar monthly is 0·064 of the main tide, which is about half as large as was obtained in the two former years; but is nevertheless much larger than it ought to be.

The lunar fortnightly agrees well with the theoretical proportion to the main tide, as has been formerly observed at Moulmein. *But perhaps the principal features of the Moulmein tides are the very large values obtained for the solar annual and luni-solar fortnigthly tides;* the former is 64 per cent and the latter 30 per cent of the main tide, and the values obtained from all three years' observations are very accordant, both as regards magnitude and epoch.

The solar annual is clearly meteorological in origin, and its epoch is about the 21st August; and this agrees well with the date on which *this tide at Rangoon* attains its maximum height.

The luni-solar fortnightly is, as has been remarked in the notes on the Rangoon tides, actually 30 per cent of the main tide, and is the highest proportion yet obtained for this tide at any port at which observations have been taken.

The solar semi-annual is about four times as great as it ought to be theoretically; this agrees with what has been formerly observed at Moulmein; its time of maximum from this year's observations appears to be about one week later than the dates obtained in the two previous years.

VALUES OF THE TIDAL CONSTANTS, AMHERST, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Amherst:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	ν	μ	*R*	*T*	*MS*	2*SM*
A_0	13·701	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_1	·096	·059	·285	·200	·207	·023	·034	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_1	97°·13	21°·20	271°·16	89°·15	263°·63	161°·07	241°·23	.....	.....	.....	.....	.....	...	...	.....	.....
R_2	2·750	6·553	.....	·161	.....	.....	.....	·204	1·371	·232	·350	·232	...	...	.....	·118
ϵ_2	104°·70	66°·93	.....	83°·33	.....	.....	.....	255°·78	49°·47	356°·30	77°·26	322°·53	...	...	.....	17°·49
R_3	.....	·020	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_3	.....	270°·73	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_4	·101	·374	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	·359	.....
ϵ_4	116°·81	35°·43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	74°·17	.....
R_5	·030	·155	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_5	118°·99	246°·12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
R_6	·000	·023	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....
ϵ_6	269°·83	218°·96	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	.....

Long-Period Tides.

Lunar monthly tide	... ...	R = ·041	ϵ = 51°·63
„ fortnightly „	... ...	R = ·100	ϵ = 3°·61
Luni-solar „	„	R = ·030	ϵ = 67°·20
Solar annual	„	R = ·814	ϵ = 129°·63
„ semi-annual	„	R = ·124	ϵ = 331°·92

The mean level of the sea (A_0) appears to be a mean between the two former values, viz. 13·704 feet above the zero of the gauge; for 1880-81 the value was 13·591 and for 1881-82 it was 13·974; but it should be remarked here that the 1880-81 observations were very incomplete.

The amplitude of the main lunar tide (R_2 of M) is a good deal larger than in either of the two former values, viz. 6·553 feet against 6·249 in 1880-81, and 6·174 in 1881-82; this value is greater than for any other port in India at which observations have yet been taken. Bhaunagar will probably give a much larger value; but as yet the observations have not been started at that port.

The main solar tide (R_2 of S) has an amplitude of 2·750 feet, which is a fairly good mean between the 1880-81 value, 2·851 feet, and the 1881-82 value, 2·705 feet.

The proportion of the main solar tide to the main lunar tide is 0·420, which is about 5 per cent less than the theoretical value: in 1880-81 the proportion was 0·456 and in 1881-82 it was 0·438. There is a close resemblance between Amherst and Dublat as regards the proportion of the two main tides to each other.

The lunar elliptic tides agree very closely in their proportions to the main tide with what was observed in the two former years, the lesser (L) is 0·045 and the greater (N) is 0·210 of the main tide; theoretically the proportions are 0·028 and 0·194 respectively, so that at Amherst, both these tides are too large.

With regard to the evectional tides, the smaller (λ) is five times as great as it ought to be; the proportion in former years was even greater, but this tide is theoretically insignificant. The larger component (ν) is, for this year, more than twice as great as it ought to be; the proportions in the two former years were also too high, but in 1881-82 it was not very much higher than the theoretical proportion.

As regards the variational tide (μ), its proportion to the main tide although slightly less than was found for last year, is still somewhat higher than the theoretical value.

The solar elliptic semi-diurnal tides have not been evaluated this year, two years' observations being required.

The luni-solar declinational semi-diurnal tide (R_2 of K) which last year agreed precisely with theory in its proportion to the main tide, is, for this year, 4 per cent too small; in 1880-81 this tide had an abnormally high proportion to the main tide, being more than double what it ought to be.

The luni-solar compound tide (2SM) is only 2 per cent of the main tide; in the two former years it was about 3 per cent.

With reference to the diurnal tides; they are (as has been found for all ports in the Bay of Bengal) very much smaller in their proportions to the main tide than the values which theory would assign. Commencing with the largest (R_1 of K), the proportion to the main tide for this year is 11 per cent, and agrees almost precisely with what obtained in the two former years, while theoretically the proportion ought to be over 58 per cent. The next largest tide of this period (R_1 of O) is only 4 per cent of the main tide; in the two former years it was 5 per cent; theoretically it is 42 per cent. The remaining diurnal tides are, with the exception of R_1 of P (which is 3 per cent of the main tide), perfectly insignificant.

With regard to the over-tides, the principal is the lunar quarter-diurnal, which has a value of 6 per cent of the main tide; last year it was 7 per cent, and in 1880-81 it was a little over 4 per cent. Compared to the value at Moulmein, this proportion is very small, but for a port situated at the mouth of a river it must be considered very high; and in fact it is almost as great as the proportion which obtains at Rangoon.

The only other over-tides of importance are the lunar sexter-diurnal and the solar quarter diurnal, the former of which is 0·023 and the latter 0·016 of the main tide.

With reference to the long-period tides, the lunar monthly is almost insignificant this year; last year it was only half as large in proportion to the main tide as it ought to be by theory.

The lunar fortnightly and the luni-solar fortnightly are each very small in their proportion to the main tide; the former of these tides appears to be at Amherst, only about 1 per cent of the main tide, while theory would give 9 per cent; the latter tide is, as it ought to be, insignificant. The solar annual tide has this year a proportion of more than 12 per cent of the main tide; this is slightly greater than the value obtained in 1881-82, and is considerably less than what is found at Dublat or at any station in the Bay of Bengal at which observations have yet been taking; its time of maximum appears to be 20 days earlier than last year, viz. about the 28th July.

With regard to the semi-annual tide; its proportion to the main tide is 2 per cent; last year it was 3 per cent, theoretically it ought to be 4 per cent; its time of maximum is very different from that obtained in 1881-82. But it must be here observed that the reduction of the long-period tides has always been carried out as if there was no break in the registration of the observations. At Amherst the observations have never been complete, and for the present year there is an interruption of 24 days; clearly, then, the values obtained for the long-period tides cannot be considered quite accurate.

VALUES OF THE TIDAL CONSTANTS, PORT BLAIR, 1882-83.

The following are the amplitudes and epochs deduced from the 1882-83 observations at Port Blair:—

Short-Period Tides.

	S	*M*	*O*	*K*	*P*	*J*	*Q*	*L*	*N*	λ	*ν*	*μ*	*R*	*T*	*MS*	*2SM*
A_0	4·710	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_1	0·016	0·014	0·149	0·267	0·134	0·013	0·021	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_1	31°·03	324°·64	221°·39	46°·14	223°·58	51°·95	152°·44	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_2	0·269	2·057	.....	0·223	.....	.....	.....	0·037	0·440	0·018	0·031	0·077	.....	.....	.....	0·029
ϵ_2	314°·32	276°·78	.....	290°·12	.....	.....	.....	78°·73	275°·02	119°·29	211°·85	287°·68	.....	.....	.....	147°·26
R_3	.....	0·007	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_3	.....	15°·07	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_4	0·001	0·011	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0·007	.....
ϵ_4	59°·94	154°·58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	232°·45	.....
R_5	0·002	0·000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_5	142°·13	37°·32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
R_8	0·001	0·002	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
ϵ_8	55°·13	313°·07	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Long-Period Tides.

Lunar monthly tide	...	... $R = 0{\cdot}005$	$\epsilon = 20^{\circ}{\cdot}70$
„ fortnightly „	...	... $R = 0{\cdot}038$	$\epsilon = 355^{\circ}{\cdot}20$
Luni-solar „ „	...	... $R = 0{\cdot}018$	$\epsilon = 11^{\circ}{\cdot}15$
Solar annual „	...	... $R = 0{\cdot}251$	$\epsilon = 155^{\circ}{\cdot}76$
„ semi-annual „	...	... R 0·110	$\epsilon = 169^{\circ}{\cdot}63$

The value of the mean level of the sea (Ao) above the zero of the gauge is 4·710 feet against 4·718 feet last year, and 4·792 feet in 1880-81.

The main solar and lunar tides agree fairly well both in amplitude and epoch with their last year's values, the amplitude of the former being slightly in defect and of the latter slightly in excess of the 1881-82 values.

From the above it is evident the proportion of the main solar to the main lunar tide agrees well with the values obtained in former years; this year it is precisely the theoretical value, being 0·466.

The larger lunar elliptic tide (N) has also precisely the theoretical proportion to the main tide, viz. 0·194, while the smaller component (L) is two per cent of the main tide against three per cent, the theoretical value.

The larger evectional semi-diurnal tide (ν) agrees this year with the theoretical proportion to the main tide: in the two former years it was twice as much as it ought to be. The smaller component (λ) is three times as much as it ought to be; but the value for this year agrees well with that obtained in the two former years.

With regard to the variational tide (μ), the proportion (now obtained) to the main tide is 4 per cent; in the two former years it was slightly higher: theoretically it ought to be a little over 2 per cent.

The luni-solar declinational semi-diurnal tide (R_2 of K), which from the two former years' observations agreed well with theory, is, for this year, slightly less than it ought to be, being 11 per cent against 13 per cent, the theoretical value.

Thus, generally speaking, the whole of the semi-diurnal tides at Port Blair agree well in proportion to the main tide with the theoretical values.

As regards the diurnal tides; they appear to follow the law which obtains along the east coast of India, viz. in being all much less in proportion to the main tide than they ought to be theoretically.

The values obtained this year agree well with those obtained in the two former years. The three largest, viz. the luni-solar diurnal, the lunar declinational, and the solar declinational, have proportions to the main tide, of 18, 7, and 7 per cent respectively, against 58, 42, and 19 per cent, the theoretical values. While at Madras and Negapatam the proportion of the chief diurnal tide was found to be from 25 to 29 per cent of the main tide, and the two other diurnal tides mentioned above, were found from 9 to 11 per cent of the main tide, values which are not very different from those obtained at Port Blair.

The remaining diurnal tides at Port Blair are quite insignificant.

The lunar and solar over tides call for no special mention; they are all small, as they ought to be, and the values now obtained agree with the two former years' values.

With regard to the long-period tides, the lunar monthly at Port Blair has always been found to be quite insignificant; the lunar fortnightly tide is 2 per cent of the main tide, a value which agrees well with what was obtained in the two former years; this tide at Port Blair seems to be about three times smaller than it ought to be.

The luni-solar fortnightly tide is quite insignificant, which agrees with theory.

The solar annual tide is 12 per cent of the main tide, a value which is almost the same as was obtained in 1880-81, so that the proportion deduced from last year's observations (1881-82), viz. 3 per cent, seems to be abnormally small.

The epoch too, of this tide, from the 1882-83 observations, agrees with that obtained from the 1880-81 observations, while the time of maximum obtained from the 1881-82 observations seemed to be a month too early.

The semi-annual tide at Port Blair agrees well with theory in all three years' observations, being from 5 to 6 per cent of the the main tide; the theoretical value being 4 per cent. Its epoch for this year agrees well with that obtained from the 1880-81 observations.

Extract from the Narrative Report, dated 28th September 1883, *of Major* W. J. HEAVISIDE, R E., *Officiating Deputy Superintendent, 2nd grade, in charge No.* 1 *Astronomical Party.*

I RETURNED from furlough to Europe, and resumed charge of this party at Fyzabad from Lieutenant-Colonel Campbell on the 6th of December 1882. The observations on the first arc, Jalpáiguri-Fyzabad, were then in progress. Major G. Strahan was at Jalpáiguri, and three nights' work on the 2nd, 4th, and 5th of December had already been completed. I commenced observing on the night of the 6th, and the eight nights' observations which it was considered desirable to employ for this arc were finished on the night of the 11th. The party then moved to Calcutta.

While the instruments were being conveyed down country, I passed on through Calcutta to Jalpáiguri, and observed for personal equation with Major Strahan. When I returned I found that Colonel Campbell, who was in Calcutta, had considerately put the instruments into position, so that I was enabled to commence observing at Calcutta for the second arc, Jalpáiguri-Calcutta, on the night of the 21st of December.

The second arc Julpáiguri-Calcutta, was finished on the 2nd of January. On the 7th, the party left Calcutta by steamer, arriving at Chittagong on the 9th. The third arc, Chittagong-Jalpáiguri, was commenced on the 12th, and finished on the 18th; the fourth arc, Chittagong-Calcutta, was commenced on the 23rd, and was finished on the 30th of January, the weather having been very fine and all things working very smoothly. On the 3rd of February, the party left Chittagong by steamer, reaching Calcutta on the 5th. The fifth arc, Calcutta-Fyzabad, was commenced on the 8th, and finished on the 14th; the sixth arc, Calcutta-Jubbulpore, was commenced on the 22nd, and finished on the 3rd of March. The party next moved up to Fyzabad, while I made a detour to Jubbulpore, observing there with Major Strahan for personal equation, and reaching Fyzabad on the 11th. The seventh arc, Fyzabad-Jubbulpore, was commenced on the 14th of March, and finished on the 20th; and the eighth and last arc was commenced on the 28th, and finished on the 4th of April. The party then moved up to Agra, where another personal equation was observed. Recess quarters at Mussoree were reached on the 19th of April, and office was opened the next day.

The work throughout the season proceeded smoothly; we lost a few nights' work owing to cloudy weather. On two occasions we failed to obtain communication owing to an interruption on the line; and two nights were lost owing to faults in our local electrical connexions.

Colonel Campbell observed at Fyzabad on the 2nd, 4th, 5th, and 7th of December, but throughout the remainder of the season, the work was carried on entirely by Major Strahan and myself.

Recess duties were commenced on the 20th of April; from the 23rd of April to the 1st of August, I had charge of both astronomical parties owing to Major Strahan's absence on duty in Calcutta. At the time of his departure Mr. Keelan was still in Burma, and Babu Harsahai had been granted privilege leave; so there remained only Babu Balwant and myself to deal with the somewhat formidable mass of figures which one season's work of these parties represents. You were therefore good enough to lend the services of two computers from the Computing Office, and it may here be stated that they continued to work under me till the 3rd of September. During the first month, they did not progress very satisfactorily, but they subsequently worked very well indeed. Mr. Keelan returned from the field on the 8th of May. Babu Harsahai returned from leave on the 20th of July, and Mr. D. Atkinson joined this party on the 3rd of August. The computing power thus represented would scarcely have sufficed to finish the computations, had it not happened that Major Strahan having fewer moves during the field season than is usual, took advantage of the leisure thus afforded to read off chronograph sheets, and to compute, so that a very considerable advance had been made in this direction before the recess commenced.

Some new procedures were adopted in observing: the pivots of the telescopes were reversed between every two nights' observations, instead of, as in former years, only once half way through the observations on each arc. Owing to the large pivot differences shown by the observations of 1881-82, some doubt had been thrown on the pivot bearings of the telescopes, which it may be remembered are of somewhat peculiar construction. To quote from volume IX of the Operations of the Great Trigonometrical Survey, "the pivots rest on nearly semi-cylindrical bearings of gun-metal of the same length and diameter as themselves, but cut away in the lower part, so that there is contact only on two arcs of about 60° each. The under surface of these bearings is spherical, fitting exactly the upper surface of the beds on which they rest, and to which they are loosely attached by a bolt passing through a slotted hole, so that the whole forms a universal joint which allows the bearings to adjust themselves under the weight of the telescope, and insures the equal bearing of the pivots throughout their length." It will thus be understood that when the telescope is removed, the pivot bearings can be turned round in azimuth; and in order to show whether the large pivot difference was due to these bearings, Colonel Campbell introduced a system for the first two arcs, by which the bearings were turned round 180°, one at a time, at both stations, in regular succession.

There is nothing to remark in the collimator, level, or azimuth results, all of which were steady and constant: collimation was determined at least twice during each night: the level was observed at least twice; and the azimuth was invariably (exceptions being due to cloudy nights) determined by two pairs of circumpolar stars, one pair near the commencement, the other near the end of the night's work.

Memorandum on personal equation as determined in connection with the Electro-Telegraph Longitude operations in 1882-83, *and the modifications consequently introduced in the computations, by* MAJOR W. J. HEAVISIDE, R.E.

In order to understand the system followed in eliminating the personal equation of the observers from the final results of the difference of longitude, Δ L., and the reasons for the modifications introduced in the computations of 1882-83, it will be advisable to enter into a short explanation of the procedure heretofore adopted, full details of which will be found in Vol. IX of the *Account of the Operations of the Great Trigonometrical Survey of India*, Chapter V, sections 4 and 5, and Chapter VI, sections 18, 19, 20, 25, 29, 30, and 31.

Two distinct personal equations dependent on the direction of a star's motion as seen in the transit telescope have been recognised in these operations since 1876. To distinguish between the two motions, Colonel Campbell introduced the terms "north aspect" and "south aspect" to indicate the direction of the observer's face when looking through the telescope, and therefore the direction of the star's motion from apparent right to left for north aspect, and from apparent left to right for south aspect. It may be remarked that these terms do not necessarily agree with the position of the star with reference to the zenith, because a star very near the zenith may be equally conveniently observed under a north or a south aspect.

Whenever an opportunity was conveniently offered for the two observers to be together, divided transits for "relative personal equation" were observed, care being taken to keep the results by stars of north aspect separate from those of south aspect. From these observations two equations were deduced of the form

$$(S_N - H_N) \text{ and } (S_S - H_S)$$

in which the capitals represent the initials of the observers and the subscripts denote the aspect under which the star was observed. The results obtained this season are exhibited in Table I. Moreover, when the two observers were at different ends of an arc, certain stars close to the zenith were observed on each night at both stations under both aspects, the observer recording the first ten wires of each of these stars under either a north or a south aspect, and then moving round the telescope and recording the last ten wires under the opposite aspect. From these observations what is termed the "absolute (N—S) equation" of the form

$$(H_N - H_S) \text{ and } (S_N - S_S)$$

was deduced for each observer at each station. The results are exhibited in Table II. Without this absolute equation such stars as happen to be observed under different aspects at the two stations of an arc cannot be properly combined.

The aspect under which each star is observed is carefully recorded throughout the season's work, and in the computations for 1880-81, printed in Volume IX, the absolute (N—S) equation for each observer is used in the first instance to deduce a value of the difference of longitude (symbolised as δL_N) such as it would have stood if all the stars of south aspect had been observed by both observers under a north aspect. This value of δL_N was then corrected for the relative personal equation, and the value of Δ L finally deduced.

In taking out the absolute (N—S) equation for 1882-83 between Majors Strahan and Heaviside, it was noticed that not only was this equation smaller than usual, but there was a tendency to a first *minus* second equation rather than to (N—S) equation; that is to say, that the time of observation over the first ten wires when reduced to the centre wire was almost invariably greater than over the last ten wires, whatever the direction of the star's motion. The values of this equation are shown in Table II under the headings

$$(S_1 - S_2) \text{ and } (H_1 - H_2)$$

The existence of this (1st—2nd) equation was first noticed by Major Strahan in his report of last year, and I have endeavoured to trace how far it enters into the results in the ordinary course of the work, when the observers are taking transits at opposite ends of an arc.

With this view I selected from each of the four arcs, which happened to be first computed, ten stars on each side of the zenith. Each star had been observed over 15 wires, and the observations to each wire had been reduced to the centre wire. From these reductions I abstracted the means of the first five wires for comparison with the means of the last five wires for each star, and denominated the difference in time the (1st—2nd) equation, so that if the result of this equation be positive, it shows that the time reduced to centre wire is greater by the first group of five wires than by the last group of five. The results are shown in Table III under the headings $(S_1 - S_2)$ and $(H_1 - H_2)$. The values are abstracted for both observers for two nights of each arc; the nights chosen are those when clouds did not interfere with the work, and are near the beginning and end of the period over which the work on that arc extended. It will be seen that the differences are small for the first arc by Major Strahan's observations, but they are larger and fairly constant in the other arcs, while the persistency of the sign shows that such an equation exists running through the work of the season.

It is difficult, if not impossible, to state at which portion of the star's transit the observation is most correct. There is evidence either of retardation over the first wires or of acceler-

ation over the last wires, but no evidence to enable us to decide which of the two affects the resulting mean: at the same time, every now and then when I am observing, I am aware of an anxiety to get on to the next star which probably causes me to hurry over the last five wires, and I should be inclined in consequence to say that the mean of the first five wires is more correct than the mean of the last five. Following up this suppositious view, it seemed probable that when one star followed another quickly, there would be more anxiety to hurry on to the second star than when the interval between the stars was large. I therefore picked out some stars which were followed by others at short intervals, but the resulting equations were very similar to those exhibited in Table III; viz.:—

In the arc Calcutta—Fyzabad,

$$(S_1 - S_2) = + \overset{\text{Sec.}}{0{\cdot}031}$$
$$(H_1 - H_2) = + 0{\cdot}035$$

And for the arc Calcutta—Jubbulpore,

$$(S_1 - S_2) = + \overset{\text{Sec.}}{0{\cdot}040}$$
$$(H_1 - H_2) = + 0{\cdot}048$$

which do not bear out this second supposition.

The question remains whether any correction can or should be applied on account of this equation. Even if it was an idiosyncrasy peculiar to one observer and fairly constant, it is but reasonable to suppose that it would be eliminated in the corrections applied for relative personal equation: it is much more likely to be eliminated when the equation is found to be common to both observers, and to differ but slightly in magnitude. No correction has been applied to ΔL for this equation, but the equation has been eliminated—

(1) From the absolute (N—S) equation in Table II, by using as many stars in which the observer commenced with a north aspect as with a south aspect.

(2) From the relative personal equation in Table III, by the system pursued of each observer commencing with alternate stars.

It will be noticed that in Table II the (1st—2nd) equation is invariably larger than the (N—S) equation, and that for the first six arcs the latter equation is very small, and in several cases less than the probable errors. It was therefore considered inadvisable to employ these values in the manner described in paragraph 4, and the absolute equation has not been used in the reductions. To eliminate personal equation from the values of ΔL the stars have been grouped according to their aspects, and the relative personal equations shown in Table I have been applied. The values employed are simple algebraical means, it having been deemed unnecessary to weigh the several results when the probable errors are in many cases very nearly as large as the values of the personal equations themselves. The observations for the first seven arcs were taken between the 1st of December and the 21st of March. The values of personal equation which have been applied for these arcs are the means of the results obtained in December and March, viz.:—

$$(S_N - H_N) = + \overset{\text{Sec.}}{0{\cdot}020}$$
$$(S_S - H_S) = + 0{\cdot}038$$

The observations for the eighth arc were taken between the 27th of March and the 5th of April, and the values of personal equation obtained two and three days later have alone been applied for this arc, viz.:—

$$(S_N - H_N) = - \overset{\text{Sec.}}{0{\cdot}008}$$
$$(S_S - H_S) = + 0{\cdot}053$$

For the nights on which Colonel Campbell observed, the values employed are:—

$$(S_N - C_N) = - \overset{\text{Sec.}}{0{\cdot}045}$$
$$(S_S - C_S) = + 0{\cdot}009$$

Table I shows the greatest variation in relative personal equation on successive nights to be sec. 0·037, and the extreme difference throughout the season to be sec. 0·044, which may, I think, be deemed highly satisfactory. Indeed the idiosyncracies of the observers as displayed in Tables I, II, and III are much more similar than appears usually to be the case, and although the inconstancy of personal equation must always leave small errors which cannot be eliminated from determinations of differences of longitude, yet we may well hope that these residuals will be smallest where the various psychological observing tendencies of the two observers are most similar.

This paper may well be closed by a comparison of the probable errors deduced from the transits of stars over 15 wires, taken by both observers in the months of December, January, February, and March. Eight nights, when the work was not interrupted by clouds, were taken at random, and for each night three slow and three quick moving stars were selected: from each of these the probable errors of a single wire and of the mean of

15 wires were determined : the general means of the forty-eight values, thus obtained, are as follow :—

	Of a single wire.	Of the mean of 15 wires.
	Sec.	Sec.
Major Strahan	p. e. ± 0·0452	± 0·0117
Major Heaviside	p. e. ± 0·0483	± 0·0124

Here again we find in the probable errors of the two observers a close agreement, which might perhaps be even closer were it not that the power of the Bohnenberger eye-piece used by Major Strahan is higher than that used by me.

Table I.

ELECTRO-TELEGRAPH LONGITUDE OPERATIONS, 1882-83.

Results of Relative *Personal Equation.*

Date of observation.	Number of stars observed under each aspect.	Resulting Relative Personal Equation. $(S_N - C_N)$.	$(S_S - C_S)$.	$(S_N - H_N)$.	$(S_S - H_S)$.	Remarks.
1882.		Sec. Sec.	Sec. Sec.	Sec. Sec.	Sec. Sec.	
17th November ...	18 north : 16 south...	−0·032 ±0·021	−0·001 ±0·019	.....	.....	
19th ,, ...	10 ,, 6 ,, ...	+0·054 ±0·025	+0·011 ±0·023	.....	.....	
17th December ...	14 ,, 16 ,, ...	.....	.....	+0·014 ±0·013	+0·059 ±0·016	
18th ,, ...	20 ,, 20 ,, ...	.....	.....	+0·027 ±0·010	+0·019 ±0·009	
21th ,, ...	10 ,, 10 ,, ...	−0·021 ±0·011	+0·022 ±0·013	.....	.....	
22th ,, ...	8 ,, 10 ,, ...	−0·032 ±0·013	+0·004 ±0·015	.....	.....	
1883.						
7th March ...	6 ,, 8 ,, ...	.....	.....	+0·033 ±0·021	+0·046 ±0·021	
8th ,, ...	24 ,, 24 ,, ...	.....	.....	−0·008 ±0·011	+0·041 ±0·014	
9th ,, ...	6 ,, ,, ...	.....	.....	+0·032 ±0·013	+0·027 ±0·022	
7th April ...	18 ,, 18 ,, ...	.....	.....	−0·004 ±0·009	+0·043 ±0·011	
8th ,, ...	18 ,, 20 ,, ...	.....	.....	−0·007 ±0·008	+0·063 ±0·026	

Note—The capitals in the heading of the columns stand for the observers' initials :—
C. for Colonel Campbell ; S. for Major Strahan ; H. for Major Heaviside.
And the subscripts denote the aspects under which the stars were observed.

Table II.

ELECTRO-TELEGRAPH LONGITUDE OPERATIONS. 1882-83.

Results of the Absolute *(N—S) Equation and of the (1st—2nd) Equation deduced from the same zenith stars.*

Station of observation.	Mean date.	Deduced Equations. $(H_N - H_S)$.	$(H_1 - H_2)$.	Station of observation.	Mean date.	Deduced Equations. $(S_N - S_S)$.	$(S_1 - S_2)$.	Remarks.
	1882.				1882.			
Fyzabad ...	7th December ...	+0·020 ±0·011	+0·033 ±0·037	Jalpáiguri ...	7th December ...	+0·018 ±0·006	+0·072 ±0·008	Colonel Campbell observed only at Fyzabad on four nights with the result that—
Calcutta ...	27th ,, ...	+0·036 ±0·009	+0·046 ±0·009	Jalpáiguri ...	27th ,, ...	+0·006 ±0·009	+0·035 ±0·003	
	1883.				1883.			
Chittagong ...	15th January ...	−0·010 ±0·009	+0·041 ±0·008	Jalpáiguri ...	15th January ...	+0·021 ±0·011	+0·039 ±0·004	$C_N - C_S$ = + 0·037 ±0·018
Chittagong ...	27th ,, ...	+0·015 ±0·006	+0·034 ±0·008	Calcutta ...	27th ,, ...	+0·026 ±0·008	+0·029 ±0·007	
Calcutta ...	11th February ...	+0·003 ±0·007	+0·042 ±0·008	Fyzabad ...	11th February ...	+0·004 ±0·007	+0·023 ±0·005	$C_1 - C_2$ = + 0·079 ±0·009
Calcutta ...	27th ,, ...	+0·013 ±0·008	+0·052 ±0·009	Jubbulpore ...	27th ,, ...	+0·003 ±0·011	+0·047 ±0·008	
Fyzabad ...	17th March ...	+0·032 ±0·009	+0·016 ±0·008	Jubbulpore ...	17th March ...	+0·032 ±0·010	+0·016 ±0·008	
Fyzabad ...	1st April ...	+0·052 ±0·008	+0·030 ±0·007	Agra	1st April ...	+0·025 ±0·009	+0·040 ±0·007	

Table III.

Abstract of Results of the (1st—2nd) Equation as deduced from transits of stars used in the determination of ΔL.

Date and Instrumental Position.	Arc.	Number of stars from which the equation was deduced.	Resulting (1st—2nd) Equations. Major Strahan. $(S_1 - S_2)$.	Major Heaviside $(H_1 - H_2)$.	Remarks.
1882.					
6th December ... ... I.P.W.	Jalpáiguri—Fyzabad	20	+ 0·009 ± 0·011	+ 0·056 ± 0·006	
9th ,, ... I.P.E.	Ditto ditto	18	+ 0·011 ± 0·012	+ 0·011 ± 0·008	
21st ,, ... I.P.W.	Jalpáiguri—Calcutta	36	+ 0·037 ± 0·011	+ 0·064 ± 0·007	
1883.					
2nd January ... ... I.P.E.	Ditto ditto	16	+ 0·016 ± 0·011	+ 0·078 ± 0·018	
6th February ... ... I.P.E.	Calcutta—Fyzabad	19	+ 0·034 ± 0·006	+ 0·032 ± 0·015	
14th ,, ... I.P.W.	Ditto. ditto	20	+ 0·024 ± 0·011	+ 0·050 ± 0·008	
22nd ,, ... I.P.W.	Calcutta—Jubbulpore	18	+ 0·017 ± 0·012	+ 0·063 ± 0·008	
23th ,, ... I.P.E.	Ditto ditto	39	+ 0·041 ± 0·009	+ 0·013 ± 0·007	

Extract from the Narrative Report dated 30th September 1883, *of* MAJOR G. STRAHAN, R.E., *Deputy Superintendent, 2nd grade, in charge No. 2 Astronomical Party.*

THE partial failure of the preceding season's work had necessitated a thorough examination and repairs of the tubes of the transit telescopes, more especially that of No. 2, to the shakiness of which the errors of the work had been traced with more or less certainty, but as this subject was exhaustively discussed in last season's report, both by Colonel Campbell and myself, it seems unnecessary to enter upon it again here.

The necessary repairs seem to have been effectively carried out, as far as could be ascertained by any tests that Colonel Campbell, then in charge of No. 1 party, and myself, could apply.

The application of these tests was the first business to which Colonel Campbell and I directed our attention on our arrival in Calcutta.

The test suggested by Colonel Campbell in paragraph 11 of last season's report was carefully applied to both telescopes in Calcutta, with the result that the two sets of readings agreed within the probable errors of observation, and that no further apprehension existed of the introduction of errors by the same cause during the present season.

Considerable difficulty had been experienced in Calcutta in seeing the reflection of the spider lines in the mercury trough when obtaining the level correction with the Bohnenberger eye-piece; and some experiments were made with a view to diminishing the vibration of the surface of the mercury, caused by the extreme instability of the Calcutta soil, an instability so great that a vibration was set up sufficient to obliterate the reflected image by the wheels of a passing carriage long before the sound of the carriage could be heard. A cough or sneeze from one of the men standing in the tent would often have the result of momentarily obscuring the image. Colonel Campbell suggested that the mercury trough should itself be made to float in a larger vessel containing mercury; a trough was also tried suspended by India-rubber rings, and also a piece of silvered glass floating on the mercury, but none of these expedients caused any appreciable abatement of the nuisance; and it seems probable that the vibration of the telescope tube itself is a more active agent in producing it than the tremor of the mercurial surface.

The state of the instruments and equipment having been pronounced satisfactory, Colonel Campbell proceeded to Fyzabad to commence the measurement of the first arc, Jalpáiguri-Fyzabad; and I proceeded to the former station for that purpose.

It will be as well in this place to mention briefly what the programme sketched out for the season was, as it was liable to alteration during the progress of the work, according as a preliminary computation of the first arcs showed that certain portions of the previous season's work were, or were not, incorrect.

For instance, the arc Jalpáiguri-Fyzabad was first undertaken, and if the approximate computation showed that the circuit Fyzabad-Jalpáiguri-Hazribagh closed satisfactorily, it would probably have been unnecessary to measure the arc Calcutta-Fyzabad; in fact a good deal of the subsequent work depended on the results of this first measurement.

It turned out, however, as suspected, that the above circuit closed with a rather large error, and then the remaining programme was finally decided on and carried out as follows:—

	Observers.	Commenced.	Completed.
Jalpáiguri	Major Strahan ...	December 21st	... January 2nd.
Calcutta	,, Heaviside ...		
Chittagong	,, Heaviside ...	January 12th	... January 18th.
Jalpáiguri	,, Strahan ...		
Chittagong	,, Heaviside ...	January 23rd	... January 30th.
Calcutta	,, Strahan ...		
Calcutta	,, Heaviside ...	Februrary 8th	... February 14th.
Fyzabad	,, Strahan ...		
Calcutta	,, Heaviside ...	February 22nd	... March 3rd.
Jubbulpore	,, Strahan ...		
Fyzabad	,, Heaviside ...	March 14th	... March 20th.
Jubbulpore	,, Strahan ...		
Fyzabad	,, Heaviside ...	March 28th	... April 4th.
Agra	,, Strahan ...		

Observations for personal equation were taken at Calcutta between Colonel Campbell and myself on 17th and 19th November; between Major Heaviside and myself at Jalpáiguri on 17th and 18th December; between Colonel Campbell and myself at Jalpáiguri on 24th and 25th December; again between Major Heaviside and myself at Jubbulpore on 7th, 8th, and 9th March; and lastly at Agra on 7th and 8th April.

These observations for personal equation were carried out precisely in the same manner as in former years and described by me in my report for last year; the results are as follows:—

	By North aspect stars.	By south aspect stars.
November 17th	S—C = −0·033	−0·001
November 19th	S—C = −0·064	+0·011
December 17th	S—H = +0·014	+0·058
December 18th	S—H = +0·027	+0·019
December 24th	S—C = −0·051	+0·022
December 25th	S—C = −0·031	+0·004
March 7th	S—H = +0·035	+0·048
March 8th	S—H = −0·008	+0·044
March 9th	S—H = +0·032	+0·027
April 7th	S—H = −0·008	+0·043
April 8th	S—H = −0·007	+0·063

The initials S., H., C., stand for Strahan, Heaviside, and Campbell, respectively.

There were some novelties in the procedure during the season under review, amongst others, it was determined during the measurement of the first two arcs to turn the Ys round in their sockets alternately when changing face, so that every possible combination of pivot and Y might occur during the measurement. This was subsequently abandoned. A more important change, and one that I believe to be a great improvement, was a change of face each night instead of only once during the whole series of observations at each station. The determinations of collimation and level corrections were more frequently made than heretofore; three determinations was the normal number for telescope No. 2 during each night's work, by which I hoped to keep a more careful watch on any abnormal irregularities, such as had occurred during 1881-82.

The party returned to recess quarters at Mussooree on April 12th. In less than a week from that date I received orders to proceed to the head-quarters office, Calcutta, to take up temporarily the duties of Assistant Surveyor-General there for three months. I accordingly made over charge of No. 2 party to Major Heaviside on the 23rd April, and proceeded to Calcutta. When I returned to Mussooree, and received back the charge of the party on the 1st August, I found the computations in a very forward state, owing to some assistance rendered by the head-quarters office, Trigonometrical Branch, Dehra, in the shape of two experienced native computers. By the middle of September all the merely mechanical work of reduction had been completed, and the more interesting task of examination and discussion of results and incorporation with previous measurements could be undertaken.

As regards the mysterious differences between the observations I. P. E. and I. P. W. At first *sight* it seems easy enough to account for these differences by supposed irregularities or difference of radii of the pivots, but a further examination shows that they can hardly be referred to so simple a cause. Let us first suppose that telescope No. 1 remains always at the eastern station, and that this is the one by some fault of whose pivots the discrepancy occurs. I shall call this discrepancy the E — W equation in future, and its value may always be obtained by subtracting the mean of the observations I. P. W. from the mean of those I. P. E. Now, if this is a positive quantity, it of course shows that for some reason the sight-line of the telescope falls either to the east of the meridian when in the position I. P. E. or to the west when in the position I. P. W., or more probably that the effect is produced by both causes equally. At first sight this might be explained by an inequality of the pivots, but this is not a competent cause, as the axis of the pivots is always re-leveled by reflection of the spider lines from mercury after reversal. Neither can it be explained by ellipticity of pivot if at least the ellipses are symmetrically placed. I can suggest no other cause but that the shape of one or both pivots is of a slightly irregular shape, so that its axis, when the telescope is pointed to the zenith, is not at the same distance from the bearing surface of the Y as when the telescope is pointed to the nadir.

This effect might be caused by the defects of one or both telescopes, but the errors of each could not be disentangled without a greater number than we possess of observations with one telescope I. P. E and the other I. P. W. This explanation, however, I must admit is completely negatived by the fact that the E — W equation has changed its sign recently, and in the face of this, I must at present admit that I can see no solution whatever of the mystery. I have collected here all available values of this equation since the commencement of the longitude operations. It should be remembered that when telescope No. 1 is at the western station, the E — W equation necessarily changes its sign, but that if the cause I have suggested above is a real one, the sign should remain constant while the relative positions E and W are unchanged.

Arcs for which No. 1 was east.				Arcs for which No. 1 was west.			
			1875-76.				
			E — W.				E — W
Bolarum	...	Bombay	+ ·042	Bolaram	...	Bellary	+ ·127
Bellary	...	Bombay	— ·048				
Madras	...	Bolaram	— ·073				
Bangalore	...	Bellary	— ·140				
Vizagapatam	...	Madras	— ·157				
Vizagapatam	...	Bellary	— ·040				
Mangalore	...	Bombay	— ·081				
			1880-81.				
			E — W.				E — W.
Deesa	...	Kurrachee	— ·215	Bombay	...	Deesa	+ ·040
Bombay	...	Kurrachee	— ·100	Jubbulpore	...	Agra	+ ·298
Jubbulpore	...	Bombay	— ·060	Jubbulpore	...	Deesa	+ ·297
Jubbulpore	...	Bolarum	+ ·004				

1881-82.

			E—W.				E—W.
Fyzabad	...	Jubbulpore	— ·189	Hazaribagh	...	Jubbulpore	+ ·080
Jalpáiguri	...	Hazáribágh	+ ·051				

1882-83.

			E—W.				E—W.
Chittagong	...	Jalpáiguri	+ ·373	Jalpáiguri	...	Fyzabad	— ·216
Chittagong	...	Calcutta	+ ·291	Jalpáiguri	....	Calcutta	— ·556
Calcutta	...	Fyzabad	+ ·199				
Calcutta	...	Jubbulpore	+ ·238				
Fyzabad	...	Jubbulpore	+ ·280				
Fyzabad	...	Agra	+ ·201				

During the season 1881-82 at alternate arcs the pivots were dissimilarly placed, *i.e.* when No. 1 was I. P. W., No. 2 was I. P. E., and *vice versâ* with the following results :—

Fyzabad-Agra No. 1 telescope E.

The values given by No. 1, I. P. W. and No. 2, I. P. E. exceeded those given by No. 1, I. P. E. and No. 2, I. P. W. by + ·504.

Calcutta-Hazáribágh No. 1 telescope E.

The excess in this case was + ·148.

Julpáiguri—Calcutta No. 1 telescope E.

The excess in this case was + ·309.

Hazáribágh—Fyzabad No. 1 telescope W.

The excess in this case was + ·018.

Owing to the unsatisfactory state of telescope No. 2 during the year 1881-82 I prefer to base no argument on the figures then obtained. It is unfortunate that these are so untrustworthy, as it prevents us from ascertaining exactly when the change of sign occurred. In the absence of any definite information it seems likely that it may have occurred when the telescopes were repaired during the recess of 1882, though, if irregularity of pivots is the cause at work, one can hardly understand how the mere strengthening of the object tubes could in any way have affected it.

I have much pleasure in acknowledging here the cordial co-operation of the Telegraph Department, and the excellent arrangements made by the various officials who have with hardly any exception been able to devote to our exclusive use a through wire connecting the stations at which we have been observing.

CALCUTTA DRAWING OFFICE.

SECTION I.

Statement showing the nature of the work performed and the progress made from 1st October 1882 to 30th September 1883.

TITLE OF MAPS.	Scale. In. Mls.	REMARKS AND PROGRESS.
India in 4 sheets	1 = 64	Additions for engraving and hill shading in brush of sheets I and III.
India	1 = 128	Prepared with additions for press.
Do.	1 = 32	Additions and corrections in boundaries, &c., for engraving, up to date.
Do.	1 = 80	Additions and corrections up to date for engraving.
Do.	1 = 96	Ditto ditto ditto.
Do.	1 = 128	Prepared for press in colours, showing imperial surveys 1881-82.
Do. (crop map)	1 = 32	Specially prepared for the Calcutta International Exhibition, 1883.
Do. (forest map)	1 = 64	
Do. (trade map)	1 = 64	
Do. (telegraph map) ...	1 = 64	
Do. (showing missionary stations).	1 = 64	
Do. (showing irrigation) ...	1 = 32	
North-West Provinces (in 2 sheets).	1 = 16	A new compilation in two sheets, in progress of outlining, &c. This map is intended to supersede the old 16-mile map of the North-West Provinces in every respect. Being compiled from the latest surveys, it is intended for a wall map, and will be engraved eventually.
Nizam's dominions (in 2 sheets) ...	1 = 16	This map is being specially compiled owing to constant demands. The best materials have been used, and the whole work of the Hyderabad Survey has been made consistent with the modern triangulation of the Great Trigonometrical Survey of India, and the topographical details have been carefully based thereon and adjusted with the adjoining surveys of Khandesh, Nimar, Hoshangabad, Betúl, Nagpur, and Chanda. This map is intended to be photo-zincographed at first in outline and then lithographed with hills.
Punjab (in 4 sheets)	1 = 16	This map has been completed in outline and photo-zincographed, but as there have been recently a good many changes made of boundaries, &c., several proofs of these sheets have been sent to the Punjab Government for the necessary corrections. The map will then be engraved, but in the meantime skeleton photo-zincographed copies will be published.
Central India Agency (in 2 sheets)	1 = 16	Additions up to date have been made for engraving, and hill shading in brush has also been prepared for etching.
Rajputana Agency (in 2 sheets) ...	1 = 16	Ditto ditto ditto ditto.
Guzerat (in 1 sheet)	1 = 16	This is a compilation recently taken in hand, and will include Guzerat, Kattywar, and Cutch, and will be engraved in the same style as the other provincial maps. The compilation is being made from all the recent surveys, and will be engraved eventually.
Provincial maps (foolscap size) for administration reports specially prepared in accordance with Government orders.		
Bengal	1 = 80	These maps have been prepared from engraved transfers to stone. Border arrangement as to foolscap size, &c., have been specially prepared for the lithographic office, besides the general index drawn up for the guidance of the lithographers.
North-Western Provinces ...	1 = 80	
Rajputana	1 = 80	
Bombay	1 = 80	
Madras	1 = 80	
Punjab	1 = 80	
Assam	1 = 80	
British Burma	1 = 80	
Nizam's dominions and Berar ...	1 = 80	
Central Provinces	1 = 80	
Central India Agency ...	1 = 80	
District Maps.		
District Gurdaspur (in 4 sheets) ...	1 = 2	This map has been commenced on account of a special requisition from the Punjab Government. The work has all been compiled and outlined, and will be soon ready for photo-zincography (for reproduction to scale), compiled from revenue survey materials after adjusting the traverse stations in terms of modern Great Trigonometrical Survey values.

CALCUTTA DRAWING OFFICE.

SECTION I.

Statement showing the nature of the work performed and the progress made from 1st October 1882 to 30th September 1883—continued.

	TITLE OF MAPS.	Scale. In.	Mls.	REMARKS AND PROGRESS.
	District Maps—concluded.			
	District Peshawur (in 1 sheet) ...	1 =	4	These constitute the *Derajat maps* specially called for by the Punjab Government on the 4-inch scale. They have been compiled and photo-zincographed with hills. Proofs have been sent to the Punjab Government for insertion of territorial changes, &c. They will be ready for publication after the final corrections have been made. These compilations will be utilized for incorporation into the new and revised atlas sheets of India.
	Do. Bannu ditto ...	1 =	4	
	Do. Dera Ismail Khan (in 2 sheets) ...	1 =	4	
	District Dera Ghazi Khan (in 2 sheets)	1 =	4	
	District Moradabad	1 =	8	Prepared from the best materials for the North-West Provinces Gazetteer Department, and lithographed.
	Do. Raipur	1 =	4	These maps have been prepared for lithography from copper-plate transfers of atlas sheets. Marginal lines, title, &c., specially drawn for the districts.
	Do. Chittagong	1 =	4	
	Do. Bankoora	1 =	4	
	Do. Mymensingh ...	1 =	4	
	Do. Noakholly	1 =	4	
	Do. Hill Tipperah ...	1 =	4	
	Do. Hooghly and Howrah ...	1 =	4	
	Do. Mymensingh & Noakholly	1 =	8	Prepared specially for the Postal Department.
	District Maps (foolscap size) for administration reports specially prepared in accordance with Government orders.			
	Districts—			
PROVINCE OF BENGAL.	Saran	1 =	8	These maps have been prepared by transfer from stone, from the old 8-mile map of Bengal. Border arrangement as to foolscap size, &c., have been specially prepared for the lithographic office, besides the general index drawn up for the guidance of the lithographers.
	Chumparun	1 =	8	
	Durbhunga	1 =	8	
	Mozufferpore	1 =	8	
	Shahabad	1 =	8	
	Monghyr	1 =	8	
	Patna	1 =	8	
	Chittagong	1 =	8	
	Chittagong Hill Tracts ...	1 =	8	
	Sonthal Parganas ...	1 =	8	
	Gya	1 =	8	
	Bhágalpur	1 =	8	
	Cuttack	1 =	8	
	Pooree	1 =	8	
	Balasore	1 =	8	
	Manbhoom	1 =	8	
	Singbhoom	1 =	8	
	24-Parganas	1 =	8	
	Backergunge	1 =	8	
	Khoolna	1 =	8	
	Bankoora	1 =	8	
	Burdwan	1 =	8	
	Midnapore	1 =	8	
	Beerbhoom	1 =	8	
	Dinagepore	1 =	8	
	Cooch Behar	1 =	8	
	Darjeeling	1 =	8	
	Jalpáiguri	1 =	8	
	Rungpore	1 =	8	
	Western Duars ...	1 =	8	
	Purneah	1 =	8	These maps have been prepared by transfer from stone from the old 8-mile map of Bengal. Border arrangement as to foolscap size, &c., has been especially prepared for the lithographic office, besides the general index drawn up for the guidance of the lithographers.
	Hooghly	1 =	8	
	Howrah	1 =	8	
	Nuddea	1 =	8	
	Jessore	1 =	8	
	Moorshedabad	1 =	8	
	Rajshahye	1 =	8	
	Bogra	1 =	8	
	Pubna	1 =	8	
	Dacca	1 =	8	
	Furreedpore	1 =	8	
	Mymensingh	1 =	8	
	Tipperah	1 =	8	
	Noakholly	1 =	8	
	Maldah	1 =	8	
	Hill Tipperah	1 =	8	
	Lohardugga	1 =	16	In one sheet (foolscap size).
	Hazáribágh	1 =	16	Ditto ditto.
	Tributary Mahals ...	1 =	16	
	Gurjat States	1 =	16	
	Sundarbans	1 =	16	

CALCUTTA DRAWING OFFICE.

SECTION I.

Statement showing the nature of the work performed and the progress made from 1st October 1882 to 30th September 1883—continued.

TITLE OF MAPS.	SCALE. In. Mls.	REMARKS AND PROGRESS.
Districts—		
NORTH-WEST PROVINCES. Dehra Dun	1 = 8	These maps have been prepared from the clear lithographed district maps on the 8-mile scale compiled and drawn in this office for the Gazetteer Department. They have been prepared with special foolscap size, border, title, &c., to be photo-zincographed to scale for publication.
Saharanpur	1 = 8	
Muzaffarnagar	1 = 8	
Bijnor	1 = 8	
Meerut	1 = 8	
Moradabad	1 = 8	
Bulandshahr	1 = 8	
Tarai	1 = 8	
Bareilly	1 = 8	
Budaun	1 = 8	
Shahjahanpur	1 = 8	
Aligarh	1 = 8	
Muttra	1 = 8	
Etah	1 = 8	
Farrukhabad	1 = 8	
Agra	1 = 8	
Etawah	1 = 8	
Mainpuri	1 = 8	
Cawnpore	1 = 8	
Jalaun	1 = 8	
Banda	1 = 8	
Lalitpur	1 = 8	
Allahabad	1 = 8	
Basti	1 = 8	
Gorakhpur	1 = 8	
Jhansi	1 = 8	
Special Maps.		
Southern Afghanistan and Peshin Valley maps—Sheet No. 5 ...	1 = 4	Compiled from the best sources.
" " 6 ...	1 = 4	Outline and printing completed, and sheets 8, 9, and 11 have been photo-zincographed in outline. Hill shading will next be done in verticals, and the series of sheets eventually published with hills in a complete form.
" " 8 ...	1 = 4	
" " 9 ...	1 = 4	
" " 11 ...	1 = 4	
Map of the Eastern Naga Hills and Manipur.	1 = 8	Prepared expressly for the Geological Survey Department.
Ditto ditto ditto ...	1 = 4	Compiled and photo-zincographed for publication.
Map of Jaunsar Bawar ...	1 = 4	Prepared for the Geological Survey Department, and to be utilized for the Atlas of India.
Map of the Allahabad district ...	1 = 8	Prepared for the Gazetteer Department, and utilized for the district foolscap size map.
Map of Egypt, sheets Nos. 1, 2, 3, and 4.	1 = 3	Prepared for photography with large scale plan of Cairo.
Gonda and Bahraich districts ...	1 = 1	Prepared with additions for press.
Sketch map of Hazarajat ...	1 = 16	
Rajputana Agency survey—		
Sheet No. 32 ...	1 = 1	Prepared with additions for press, for urgent publication.
" " 35 ...	1 = 1	
" " 36 ...	1 = 1	
" " 37 ...	1 = 1	
Northern Waziristan ...	1 = 2	
North-West Provinces ...	1 = 16	Showing medical charitable dispensaries, specially prepared for Surgeon-General, North-West Provinces and Oudh.
Map of the Behar Opium Agency	1 = 16	Compiled specially for the Opium Department.
Ditto Benares ditto ...	1 = 16	
Ditto Behar and Benares Agencies combined in one.	1 = 32	
Provincial index map of the Punjab.	1 = 32	Prepared in accordance with the orders of the Surveyor-General, with continuous numbers to the standard 1-inch sheets throughout the province.
Provincial index map of the Central Provinces.	1 = 32	In hand, being prepared in accordance with the orders of the Surveyor-General, with continuous numbers to the standard 1-inch sheets throughout the province, prepared for photograph reduction to ½ths.
Provincial index map of Bengal ...	1 = 32	
Ditto of Assam ...	1 = 24	
Index map of the Rajputana Agency.	1 = 24	In hand, and being prepared as above.
Index map of the Central India Agency.	1 = 24	

CALCUTTA DRAWING OFFICE.

SECTION I.

Statement showing the nature of the work performed and the progress made from 1st October 1882 to 30th September 1883—continued.

TITLE OF MAPS.	Scale.	REMARKS AND PROGRESS.
Special Maps—concluded.	In. Mls	
Index map of Afghanistan ...	1 = 32	Prepared in accordance with orders from Surveyor-General.
Ditto of Baluchistan ...	1 = 32	
Bengal	1 = 16	Prepared with additions for press.
Assam	1 = 24	Prepared for the Census Department.
Map showing tribal distribution of country north of Peshawar.	1 = 4	Prepared for Officiating Secretary to the Government of the Punjab, drawn for photo-zincography.
Peshawar with northern tribal names.	1 = 4	
Punjab	1 = 32	Prepared for Census Department.
Sheets of the Atlas of India.		
4 S.W. (New edition) ...	1 = 4	Compiling from recent surveys in Northern Afghanistan for engraving.
14 S.E., 14 N.W., 14 N.E. Ditto	1 = 4	
22 S.E. Ditto	1 = 4	Compiled a small portion from the Kattywar survey for engraving.
27 A. Ditto	1 = 4	Compiled a small portion of the Hazara District for engraving.
28 Full Ditto	1 = 4	Compiled from new survey of Hazara; old portions revised for engraving.
30 Full, 31 Full Old edition ...	1 = 4	Correction of names in accordance with modern spelling for engraving.
35 S.E., 36 N.E. New edition ...	1 = 4	Hill shading in brush for engraving.
37 S.E., 37 S.W. Ditto	1 = 4	Additions for engravers.
38 S.E., 39 N.E. Ditto	1 = 4	Compiled from old Hydorabad survey and adjusted with the new survey of Khandesh adjoining the Nizam's dominions, for engraving.
47 Full, 48 Full Old editions ...	1 = 4	Correction of names in accordance with modern spelling, for engraving.
48 S.W. New edition ...	1 = 4	Additions for engraving.
49 N.W. Ditto	1 = 4	Compilation from new survey of the Delhi District, for engraving.
49 S.W. Ditto	1 = 4	Compilation from new survey of the Gurgaon District, for engraving.
49 S.E. Ditto	1 = 4	Compilation from new survey of the Delhi District, for engraving.
49 N.E. Ditto	1 = 4	Compiling from new surveys of districts Delhi, Karnal, and Rohtak, for engraving.
50 N.E. Ditto	1 = 4	Compilation from new survey of the Muttra District, for engraving.
50 S.E. Ditto	1 = 4	Compilation from new survey of the Agra District, for engraving.
55 Full Ditto	1 = 4	Hill shading in brush, for engraving.
66 S.W. Ditto	1 = 4	Additions and junglo, &c., for engraving.
67 S.W. Ditto	1 = 4	Compiling from new survey of the Moradabad District, for engraving.
69 N.E. Ditto	1 = 4	Compilation from new survey of the Banda District, for engraving.
69 S.E. Ditto	1 = 4	Hill shading in brush, with additions, for engraving.
88 S.W. Ditto	1 = 4	Compilation from new survey of the Banda District, for engraving.
89 Full Ditto	1 = 4	Compiling and revising a small portion of the Banda District, for engraving.
103 Full Ditto	1 = 4	Additions for engraving.
114 N.E., 114 S.E., 114 N.W., 115 N.E. Ditto	1 = 4	Compiled from new survey of the Midnapur District, for engraving.
125 S.E. Ditto	1 = 4	Compiling from new surveys of portions of Sylhet and Cachar in progress for engraving.
131 N.E., 131 S.E. Ditto	1 = 4	Compilation from the new survey of the eastern and southern portions of Manipur, also hill shading in brush for engraving.

N.B.—In addition to the above, a great deal of miscellaneous work has been done from time to time in atlas sheets, such as insertion of new roads, canals, railways, &c. These small jobs are too numerous to be particularised in the above columns.

CALCUTTA DRAWING OFFICE.

SECTION I.

Statement showing the nature of the work performed and the progress made from 1st October 1882 to 30th September 1883—concluded.

TITLE OF MAPS.	Scale. In. Mls.	REMARKS AND PROGRESS.
Miscellaneous Maps, Tracings, &c.		
Himalayan route map ...	1 = 32	Additions in drainage for Northern India, &c., inserted from General Walker's Turkestan for engravers.
Kristnas route map	1 = 32	Preparation of sketch map from Kristna's verbal account of his route to and from lake Kokonur, *viâ* Lhassa and back, through Ta tsien-lu, Batang, &c., constructed by Mr. A. Chamarett.
Punjab, old edition—		
Sheet No. 1 ...	1 = 8	Corrected up to date as far as possible for second issue.
" " 2 ...	1 = 8	
" " 3 ...	1 = 8	
" " 4 ...	1 = 8	
" " 5 ...	1 = 8	
" " 6 ...	1 = 8	
" " 7 ...	1 = 8	
" " 8 ...	1 = 8	
District Chittagong ...	1 = 16	Corrected up to date and prepared for press. Special maps for the Census Commissioner of Bengal.
" Rajshahye ...	1 = 16	
" Cooch Behar ...	1 = 16	
" Patna	1 = 16	
" Bhágalpur ...	1 = 16	
" Chota Nagpur ...	1 = 16	
Map of country around Lahore ...	1 = 2	Prepared for press.
Presidency Division map ...	1 = 16	For Census Department.
Plan of the city of Kohat ...	12 = 1	Prepared for publication to scale.
Plan of the city of Ajmere ...	12 = 1	Prepared with additions for new issue.
Eastern Naga Hills and Manipur	1 = 8	Prepared for the Geological Survey Department. Drawn with hills for lithography.
India in two separate portions, Punjab in one and North-West Provinces in the other.	1 = 256	Prepared for the Meteorological Department.
India (rainfall maps) ...	1 = 64	
Map of Lower Egypt ...	1 = 6	Prepared for publication.
India (map showing the emigration from each district in Bengal).	1 = 64	
Map of India, No. 2	4 = 128	Corrected and colored up to date for press.
Two plans of tidal curves ...	.....	Typed for reduction by photo-zincography.
Madras Presidency	1 = 32	Prepared from lithograph transfer, with border, heading, &c., specially arranged (for issue).
Bombay ditto	1 = 32	
Map of the Central Provinces ...	1 = 16	Corrected up to date (for publication.)
Map of India	1 = 64	Prepared for the Agricultural Revenue Department.
Map of Bengal in 16 sheets ...	1 = 8	Corrected up to date for new issue.
Ulwar State	1 = 4	Corrected for publication.
241 Originals and proofs examined and corrected for photography and lithography.	Various scales	Entered in counterfoil receipt book and despatched.
3,363 Sheets of various maps, colored.	Ditto	Colored as office standard copies and for press.
22,154 Colored maps examined.	Ditto	Examination of colored maps intended for general issue.

N.B.—In addition to the above, various miscellaneous small jobs, such as tracings, pentagraphing, hand-printing, typing, coloring, &c., have been performed by the drawing office, as well as projections and plotting when necessary.

A. CHAMARETT, *Surveyor, 1st grade,*
Chief Draftsman.

C. STRAHAN, *Major*, R.E.,
Assistant Surveyor-General,
In charge Drawing Office.

SURVEY OF INDIA OFFICE,
Calcutta, 20th December 1883.

CALCUTTA DRAWING OFFICE.

SECTION II.

TITLE OF MAPS.	Scale.	REMARKS.
Punjab.	Inch. Mile.	
Districts Bannu, Dera Ismail Khan, and Thal of Muzaffargarh, in 44 standard sheets, 30′ × 15′.	1 = 1	The geographical lines inserted on 151 of the 4-inch maps comprising standard sheets Nos. 34, 35, 37, 38, 40, 41, 42, 42A, and 42B, and sent to press for photographic reduction to ½ scale. The 2-inch sheets Nos. 18, 19, 22, 23, 26, 27, 30, 31, and 36 were completed, and sent to press with final press order. The 2-inch blue prints of sheets 34, 35, 37, 38, and 40 have been typed and drawn, and are in a well advanced state. Sheets 39, 40, and 42 are being completed to margin by the insertion of the Muzaffargarh villages adjoining the Thal, which has been resurveyed. Number of sheets published up to date, 34.
District Rawalpindi, Kala Chitta Pahar, in 27 sheets, measuring 7′ 30″ × 3′ 45″.	4 = 1	The remaining 14 sheets, Nos. 1, 2, 3, 6, 7, 8, 9, 12, 13, 14, 19, 20, 21, and 26, prepared in the Executive's office, were carefully examined for reproduction to full scale, and passed with final press order. All published.
North-West Provinces.		
Districts Moradabad, Budaun, Tarai, part of Rampur State, in 22 standard sheets, 30′ × 15′.	1 = 1	The proofs of sheets 31, 32, 33, 34, 47, 48, 50, 51, 52, 65, 66, 67, 68, 69, 70, 84, and 85 were examined and passed with final press order. The first proofs of sheets 30 and 46 likewise have been examined and sent to press, and the two remaining 2-inch sheets, 63 and 64, have been carefully examined, corrected, and passed for final press order. This completes the districts. Number of sheets published, 20.
District Banda, in 16 standard sheets, measuring 30′ × 15′.	1 = 1	The remaining eight standard sheets, 112, 112A, 127, 128, 142, 143, 155, 156, have all been drawn, examined, and sent to press, besides sheets 109, 110, 111 which were Examined and drawn last year. The proofs of sheets 124, 125, and 140 were examined and passed with final press order. Number of sheets published up to date, 9.
Meerut division, districts Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, and Aligarh for reproduction (showing village boundaries) to scale, in ¼ sheets, 15′ × 7½′.	2 = 1	The proofs of sheets 2, 3, 4, 17, 18, 29, 30 and 31 have been examined and passed with final press order. The original sheets drawn in the Executive's office have been received, *viz.*, 5, 6, 7, 8, 9, 19, 20, 32, and 33. These were examined. All corrections made and sent to press. Number of sheets published up to date, 25.

CALCUTTA DRAWING OFFICE.

SECTION II—*continued.*

TITLE OF MAPS.	Scale.	REMARKS.
North-West Provinces—concluded.	Inch. Mile.	
For reduction (without village boundaries) to half scale, 30′ × 15′.	1 = 1	Standard sheets 17 and 18 prepared in the executive's office were re-examined and sent to press for a second edition, to meet an urgent requisition made by the General commanding the Meerut Division. Sheets 8, 9, 19, 20, 32, and 33 have been carefully examined, corrected, and sent to press.
Oudh (new edition), in 64 sheets, standard size, 30′ × 15′.	1 = 1	The original maps with graticule lines inserted comprising 15 standard sheets, Nos. 86, 87, 88, 101, 102, 103, 104, 116, 117, 118, 119, 131, 132, 133, and 134, have been sent to press for lithography. Number of sheets printed up to date, 15.
District Banda, 13 sheets, showing forest reserves.	4 = 1	The geographical lines have been inserted on 13 of the 4-inch maps of district Banda, *viz.*, Nos. 89, 90, 91, 92, 109, 110, 111, 112, 113, 114, 115, 130, 131. These maps were specially prepared for the Superintendent of Forest Surveys, Naini Tal. They were re-examined in the head office, and sent to press for publication.
Allahabad division, district Jaunpur, showing village boundaries, for reduction to half scale, 30′ × 15′.	2 = 1	The originals of eight sheets drawn in the executive's office have been received, *viz.*, Nos. 165, 166, 167, 178, 179, 180, 181, 195. These have been carefully examined in the head office, corrected, and sent to press. The final press order for the sheets has been given. All published.
Reduction for Atlas of India, portions of sheets 49 N.E. and S.E., and of sheet 67 S.W. containing portions of districts Muzaffarnagar and Meerut; also sheets 40 N.E. and S.E. containing portions of districts Sholapur, Satara, and independent States; sheet 39 S.W., district Ahmednagar, and portion of sheet 57 east of longitude 76° 30′.	.....	These were prepared in the executive's office, re-examined in the head office with the 1-inch sheets, corrected, and sent to the engraving office.
Bengal.		
District Jalpáiguri, in 13 sheets, 30′ × 15′.	1 = 1	Lithographic proofs returned by the Deputy Commissioner have been completed, to show thana boundaries, awaiting the final sanction of Government with respect to these boundaries. Press order has been deferred pending above sanction.

CALCUTTA DRAWING OFFICE.

SECTION II—*continued.*

TITLE OF MAPS.	Scale.	REMARKS.
Bengal—concluded.	Inch. Mile.	
District Mymensingh, in 23 sheets, 30′ × 15′.	1 = 1	The geographical lines have been inserted on the main circuit maps comprising sheets Nos. 343, 344, 345, 346, 347, 348, 349, 359, 360, 362, 363, 364, 374, 376, 377, 378, 388, 389, 390, 391, 392, (with two exceptions 361 and 375 reported on last season), and skeleton standards of these sheets showing the limits of main circuits, &c., have been projected for the guidance of the lithographic branch in preparing the transfer drawings to be put down on stone. The skeleton standards with main circuits have been sent to the lithographic office.
District Noakholly, in 12 sheets, 30′ × 15′.	1 = 1	The remaining sheet, No. 12, has been published, and the publication of the entire district is now complete.
District Pooree, Killah Khorda, in 65 imperial sheets.	4 = 1	Geographical lines have been inserted on all 65 of the 4-inch maps, including the 40 sheets examined and touched up last year, the proofs of which to hand, have had the geographical lines inserted thereon, and sent to press. Twenty-five sheets of this district are now still in hand. The drawing has very nigh been completed, and the typing of a few sheets remain to be taken up. Number of sheets published up to date, 40.
Bankipore civil station ...	10 = 1	The geographical lines have been inserted. The map was examined and completed for reproduction to full scale in 3 sections, and sent to press for a second edition. Proofs have been passed with final press order.
Assam.		
District Darrang, sheets 3, 5, 8, and 9	1 = 1	The proofs of sheets 3, 5, 8, and 9 were examined and passed with final press order for a second edition.
Burma.		
District Hanthawaddy, sheets 123, 124, 132, and 133, in 11 sections, measuring 15′ × 7½′	2 = 1	These sheets were drawn in the executive's office, and were re-examined, compared with the cadastral plans very carefully in the head office, and sent to press for publication to scale for the use of the local Government. Sheet 124 having been completed up to margin in the executive's office, was examined and sent to press.
Bombay.		
Deccan topographical survey, including the Konkan, in 123 sheets, 30′ × 15′, to latitude 16° N.	1 = 1	The proofs of sheets 61, 62, 68, 75, 76, 77, 84, 85, and 86 were examined and passed with final press order. S.W. section of sheet 40 having been received from the executive's office was examined, corrected, and sent, with the other sections for a second edition, to press for reduction and publication. Sheets 60, 66, 67, and 90 were also received from the executive's office, carefully examined, and sent to press for final publication.

CALCUTTA DRAWING OFFICE.

SECTION II—*continued.*

TITLE OF MAPS.	Scale.	REMARKS.
Bombay—concluded.	Inch Mile.	
Quarter sheets, each $15' \times 7\frac{1}{2}'$; 14 complete sheets, and portions of 7 sheets were published on full scale of survey to meet requirements as noted.	2 = 1	The proofs of sheets 75, 76, 77, 84, 85, 86, and 14 N.W and S.W., sheet 18 complete, sheet 22 N.W. and S.W., and sheet 26 N.W. were examined and passed with final press order for the Forest Department. The original sheets Nos. 4, 40, 41, 46, 47, 48, 52, and 53 were re-examined in this office, and prepared for reproduction to full scale for the Forest Department, and proofs of these passed with final press order.
Index Maps.		
Districts Mirzapur, Ghazipur, Ballia, Benares, Gorakpur, Hanthawaddy, Pegu, Shoaygeen and Toungoo, Bassein and Henzada, Tharrawaddy, Prome, River Hooghly, Tarai, Deccan, and Konkan, district Hissar, Punjab.	On various scales.	The index maps of districts Gorakpur Hanthawaddy, Pegu, Shoaygeen and Toungoo, Bassein and Henzada, district Tarai, and district Hissar have been re-drawn in this office; the others have been revised and brought up to date for the annual report of 1882-83.
Map of India showing density of population in 1881 to 1883.		Prepared for the Calcutta International Exhibition.
Map of India showing density of population in 1883.		
Map of India showing basins of the large rivers.		
Miscellaneous Traces, &c.		
Ganges river between Bijnor and Saharanpur.	2 = 1	Traced for Deputy Superintendent of Survey.
Northern boundary, Damin-i-koh ...	.....	For Commissioner
Boundary of Damin-i-Koh as surveyed by Captain Tanner in 1832.	2 = 1	
Boundary of Damin-i-Koh as surveyed by Lieutenant Stewart in 1865.	2 = 1	
Boundary between districts Lohareo, Jhind, Patiala, Sirsa, and Hissar.	4 = 1 2 = 1	For Deputy Superintendent of Survey.
13 Old mahalwar maps of district Sylhet.	16 = 1	Traced to illustrate report on Sylhet test survey.
Plans of 26 villages, district 24-Pargana, and 1 village of district Moorshedabad.	4 = 1	For Collector.
Ganges river and country adjoining both banks near Rampoor Bauleah compiled from old survey plans.	4 = 1	For Collector of Rajshahye.
Ganges river and one line of villages on right bank from Seebnagar Dear to Ritah.	4 = 1	
Plotted and prepared certain villages of districts Moorshedabad and Rajshahye.	4 = 1	
4 Atlas sheets, Ganges Deara Survey.	4 = 1	For Collector.
3 Village plans of district Balasore	4 = 1	
Sheets No. 3 and 5, district Manbhoom.	4 = 1	For Executive Engineer.

CALCUTTA DRAWING OFFICE.

SECTION II—*continued.*

TITLE OF MAPS.	Scale.	REMARKS.
Miscellaneous Traces, &c.—concluded.	Inch. Mile.	
Ranigunge town and Burdwan city with adjoining country for 3 miles.	4 = 1	For Assistant Superintendent, Telegraph Department.
Plotted and traced survey stations of 3 villages, district Bhágalpur, along Damin-i-Koh boundary, from Captain Sherwill's survey of 1846-47.	2 = 1	For Commissioner.
Boundary of Damin-i-Koh as surveyed by Captain Stewart in 1866-67.	4 = 1	
Index maps of Bengal, N.-W. Provinces, and Punjab showing season and character of survey.	1 = 32	For drawing office.
5 Village plans of district Shahabad	4 = 1	For Board of Revenue, Lower Provinces.
Supplied copy of field-book, and inserted survey stations and boundary of taluka Mehor, district Rohree (Sindh) on sheets Nos. 18, 19, and 20.	1 = 1	For Commissioner.
Two traces of boundary between pillars 1 and 4 and 29 to 32, also a line of adjoining villages, district Baraich (Oudh), along Nepal frontier.	4 = 1	
4 Village plans of district Mymensingh.	4 = 1	For Collector of Pubna.
Deccan sheet No. 6 of country bordering on Khandesh.	2 = 1	For Deputy Superintendent.
Traced eastern edge of sheet No. 3, Deccan series.	2 = 1	
Boundary common to pargana Dilwarpur, Bachaur, and Muheynd, district Tirhoot, along Nepal.	4 = 1	
Sheets Nos. 4 and 6, Deccan charts	2 = 1	Traced for Deputy Superintendent.
Skeleton plots of 8 sections showing traverse lines and village sites of sheets Nos. 37 and 38, Deccan.	2 = 1	Traced for Colonel Laughton.
3 Grants of district Sibsagar ...	4 = 1	For Commissioner.
Deccan sheet No. 6	2 = 1	Traced for Conservator of Forests.
Inserted old course of Ganges river on published sheets Nos. 5, 6, and 9 of district Moorshedabad, and sheet No. 2 of district Nuddea.	1 = 1	For Collector.
Map colouring.	*No. of maps.*	
Maps on various scales	213	For Surveyor General's office.
Ditto ditto	213	For Deputy Surveyor-General's office.
Ditto ditto	1,040	For India office.
Ditto ditto	1,264	For district officials.
Total ...	2,730	
Examination of Proof-sheets.		
Photo-zincographed maps ...	47	
Lithographed maps	46	

CALCUTTA DRAWING OFFICE.

SECTION II—*concluded.*

Description of Work.	REMARKS.
Computations examined.	
Districts Dera Ismail Khan and Bannu 1879-80	Final examination.
District Hanthawaddy 1879-81	
Ditto Tharrawaddy 1880-81	
Meerut Division Survey 1880-82	
Traverse data, &c., supplied.	
Of district Sylhet, along Hill Tipperah ...	For Deputy Superintendent.
Of the Hissar Division, along district Hissar (Major Johnstone's survey).	
Of district Jalpáiguri, along district Darjeeling ...	„ Assistant Settlement Officer.
Of ditto Balasore, along Mohurbhunj State ...	„ Collector.
Of ditto Sarun, along Nepal	„ Deputy Superintendent.
Of the Damin-i-Koh boundary (old and new surveys)	„ Commissioner, Bhágalpur Division.
Of 15 villages of district Budaun	For Deputy Superintendent.
Of 5 villages of district Bhágulpur	„ Collector.
Alphabetical Indexes of district Bassein (4 copies) ...	„ Settlement Officer.
Ditto ditto Tharrawaddy (4 copies)	
Field area statements (41 pages)	„ the International Exhibition.
Areas of villages along the Ganges and Ghogra rivers, in district Shahabad.	„ Deputy Superintendent.
Miscellaneous Work.	
Preparation of a table of convergency correction for every 5′ of latitude, from Lat 8° to 35°.	
Preparation of statement showing the average size of villages in Bengal by districts, by divisions, by provinces.	For Secretary, Agricultural Department.
Preparation of a statement showing thanna areas of 23 districts in Bengal.	For Government, Bengal.
Area statement of district Kamrup, by Summation of villages.	„ Deputy Commissioner.
Calculation of co-ordinates for the projection of districts Gurdaspur, Montgomery, Tirhoot, and Pooree (Khorda estate); and additional points for Jaunpur, Midnapur, Banda, and Hazara.	

S. M. SMYLIE,
Surveyor.

C. STRAHAN, *Major*, R.E.,
Assistant Surveyor-General,
In charge Drawing Office.

SURVEY OF INDIA OFFICE,
Calcutta, 20th December 1883.

WORK DONE BY THE EXAMINING BRANCH FROM 1ST OCTOBER 1882 TO 30TH SEPTEMBER 1883.

Subjects examined ...	Original standard sheets, large scale plans, and triangulation charts of topographical surveys	46
	Original compilations of parts of atlas sheets and other maps compiled in survey of India offices	57
	Engraved proofs in outline and names, &c., in various stages, as well as of general and provincial maps	150
	Photographed and lithographed proofs on various scales, including maps, plans, atlas sheets, &c., together with additional work of corrections in territorial changes and public constructions, such as boundaries, canals, roads, &c.	222
Hill shading in brush and pen	Atlas sheets in brush, and maps in pen-work	2
Work compiled... ...	Portions of atlas sheets and provincial maps, &c.	7
Projection of graticule ...	Projection of atlas sheets, and district and provincial maps ...	31
Miscellaneous	Tracings of sketches, charts, and supply of geographical data to various officials, computation of graticule for the plates of the Indian Atlas, and projection of the same on copper, calculation of areas, &c.	

G. A. McGILL,
Surveyor, 1st grade.

C. STRAHAN, *Major*, R.E.,
Assistant Surveyor-General,
In charge Drawing Office.

SURVEY OF INDIA OFFICE,
Calcutta, 20th December 1883.

CALCUTTA DRAWING OFFICE.

SECTION III.

State of Publication of Cadastral Maps on the 30th September 1883.

DISTRICTS.	NUMBER OF SHEETS.							REMARKS.
	MAPS PREPARED.			PUBLISHED.				
					DURING 1883.			
	Up to 30th September 1882.	Added during past 12 months.	Total up to 30th September 1883.	Up to 30th September 1882.	By Surveyor-General's office.	Total to 30th September 1883.	Remaining to be published.	
N.-W. Provinces.								
Agra	2,924	.....	2,924	2,924	.....	2,924	.....	
Azamgarh	930	.....	930	930	.....	930	.....	
Banda	3,317	.....	3,317	3,317	.....	3,317	.....	
Bijnour	31	.....	31	31	.....	31	.....	
Ghazipur and Ballia ...	4,004(a)	993	4,997(b)	3,073	1,056	4,084	913	(a) Figures of previous return have been changed to agree with final results.
Hamirpur	2,926	.....	2,926	2,926	.....	2,926	.....	
Jaunpur	3,434	.....	3,434	3,434	.....	3,434	.....	
Moradabad and Terai ...	4,023	.....	4,023	4,023	.....	4,023	.....	(b) These figures are liable to alteration until publication has been completed.
Muttra	1,658	.....	1,658	1,658	.....	1,658	.....	
Mirzapur	2,852(a)	886	3,738(b)	1,751	855	2,606	1,132	
Terai	57(a)	37	94(b)	15	40	55	39	
Total ...	26,156	1,916	28,072	24,037	1,951	25,988	2,084	
British Burma.								
Bassein	2,147(a)	567	2,714(b)	939	1,054	1,993	721	
Hanthawaddy and Pegu ...	3,078(a)	807	3,885(b)	2,124	924	3,048	837	
Henzada	.....	139	139(b)	.....	.....	.....	139	
Tharrawaddy	1,137(a)	959	2,096(b)	309	765	1,074	1,022	
Total ...	6,362	2,472	8,834	3,372	2,743	6,115	2,719	
Bengal.								
Patna and Gya	3,054	.....	3,054	3,054	.....	3,054	.....	
Shahabad	4,924	.....	4,924	4,924	.....	4,924	.....	
Pooree (Khorda estate) ...	3,984	730	4,714(b)	1,114	521	1,635	3,079	
Total ...	11,962	730	12,692	9,092	521	9,613	3,079	
Assam.								
Sylhet	61	.....	61(b)	16	.....	16	45	
Total ...	61	.....	61	16	.....	16	45	
GRAND TOTAL, N.-W. PROVINCES, BURMA, BENGAL, AND ASSAM	44,541	5,118	49,659	36,537	5,195	41,732	7,927	

Detail of Examination in connection with Publication.

PROVINCE.	NUMBER OF SHEETS.				REMARKS.
	Examined and rendered suitable for photo-zinco-graphy.	Traced and examined for zincography.	Proof copies examined previous to press order.	Coloured and subsequently examined.	
North-West Provinces	1,310	731	1,958	1,861	Scale, 16 inches = 1 mile.
British Burma	1,600	926	2,757	2,723	Scale, 16 inches = 1 mile.
Bengal	349	19	543	521	,, 32 ditto.
Assam	.....	.....	.....	.....	,, 16 ditto.
Total ...	3,259	1,676	5,258	5,105	

J. H. O'DONELL,
Surveyor.

C. STRAHAN, *Major*, R.E.,
Assistant Surveyor-General,
In charge Drawing Office.

SURVEY OF INDIA OFFICE,
Calcutta, 1st October 1883.

PROGRESS REPORT OF THE ENGRAVING OFFICE FROM 1ST OCTOBER 1882 TO 30TH SEPTEMBER 1883.

General Maps, &c.

Title of Maps, &c.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
	Sq. in.	Letters cut.	Sq. in.	
Map of India, scale 1 inch = 32 miles—				
Sheet 1	159	13,055	.....	Additional outline and writing done.
„ 3	.....	5,163	.....	
„ 4	.....	.....	24 H.	Slight additions and corrections to railways and writing done. Hills in progress.
„ 5	.....	.....	44 H.	Finished.
„ 6	.....	.....	.....	
Map of India in four sheets, scale 1 inch = 64 miles ...	115	12,324	96 H.	Additional outline, writing, and railways done; hills in progress; plate nearly finished.
Skeleton map of India in four sheets, scale 1 inch = 64 miles	.....	18,907	.....	Heavy additions to outline and writing; title cut. Writing in progress.
Map of India in two sheets, scale 1 inch = 80 miles ...	10	623	.....	Heavy additions to outline and writing; title cut; plate finished.
Map of India, scale 1 inch = 96 miles	.....	7,063	.....	Additions and corrections to outline and writing done. Plate finished.
Map of India No. 2, skeleton	.....	900	.....	Heavy additions and corrections to outline, writing, and railways done.
India in outline, very small ...	.....	.....	.....	Border corrected and engraved.
Map of Central Provinces in two sheets, scale 2 inch = 16 miles	.....	29	42 H.	Slight corrections and additions to outline and writings done; plates finished.
Map of Rajputana in two sheets, scale 1 inch = 16 miles	39	2,150	.....	Additional outline, writing, and railways done. Plates finished up to survey.
Map of Central India Agency, in two sheets, scale 1 inch = 16 miles	18	1,742	99 H.	Additional outline and writing done.
Map of Assam, scale 1 inch = 16 miles	5	104	60 H.	Slight additions and corrections to outline and writing done. Hills in progress.
Map of Punjab, in four sheets, scale 1 inch = 16 miles ...	.....	728	.....	Border and outside figures engraved. Waiting drawings.
Map of Himalayan routes, scale 1 inch = 32 miles ...	76	36,600	.....	New outline, writing, and title engraved; plate in progress.
Map of Berar, scale 1 inch = 8 miles	.....	16,387	.....	Outline and writing nearly finished; writing in progress.
Index chart to Great Trigonometrical Survey	.....	.....	.....	Slight corrections to outline and writing done.
Strange's zenith sector, frontispiece	.....	85	.....	Additional writing finished.
Strange's zenith sector, five other plates	.....	1,731	.....	All five plates corrected and finished.
Transit telescope	.....	100	.....	Slight additions; plate finished.
Idiometer by Colonel W. M. Campbell, R.E.	.....	100	.....	
Chronograph	.....	100	.....	
Commutator board	.....	743	.....	Finished.
Aden triangulation	.....	653	.....	
Bellary connection	.....	1,189	.....	
Carried forward ...	422	120,446	365 H.	

PROGRESS REPORT OF THE ENGRAVING OFFICE FROM 1ST OCTOBER 1882 TO 30TH SEPTEMBER 1883.

General Maps, &c.—concluded.

Title of Maps, &c.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
	Sq. In.	Letters cut.	Sq. In.	
Brought forward ...	422	120,446	365 H.	
Kater's convertible pendulum, plate K II	.....	594	.....	Finished.
Paper graticule plate, scale 1 inch = 2 miles	.....	715	.....	
Paper graticule plate, scale ½ inch = 4 miles	.....	806	.....	
Paper graticule plate, scale 1 inch = 8 miles	.....	495	.....	
Paper graticule plate, scale 1 inch = 16 miles	.....	464	.....	
Paper graticule plate, scale ¼ inch = 32 miles	.....	472	.....	
Paper graticule plate, scale 1 inch = 64 miles	.....	472	.....	
Five plates for Geological Survey in heliogravure ...	.....	2,432	.....	
Plan of Simla and Jutog, in heliogravure	.....	620	.....	
Plan of Simla and Jutog ...	.....	256	.....	Corrections and additions done.
Imprint plate (new)	.....	2,654	.....	Finished.
Note for double heights ...	.....	401	.....	
Tint No. 13, 22" × 13" ...	.....	.....	.....	Ruled and finished.
Tint No. 14, ditto	.....	.....	.....	
Tint No. 15, ditto	.....	.....	.....	
Two tints for Poona, each 18" × 11"	.....	.....	.....	
Imprint plate	.....	576	.....	Dates altered and finished.
Numbers engraved on 15 tint plates	.....	358	.....	Finished.
Chronometer	.....	.....	.....	Drawn and finished.
Three small specimen tints ...	.....	.....	.....	Ruled and finished.
Two views of Kanchinjinga in heliogravure	.....	918	.....	Finished.
Specimen plate of jungle ...	.....	.....	8 H.	Etched and finished.
Total ...	422	132,399	373 H.	

Indian Atlas sheets (new) completed and published.

Atlas sheets—				
8 N.E.	.....	3,200	163 S.H.	Completed up to limits of survey.
13 N.E.	.....	422	92 H.	Completed up to margin.
31 S.W.	.....	656	39 S.H.	
31 S.E.	.....	576	60 S.H.	
66 S.W.	.....	352	12 H.	
71 S.E.	.....	317	39 H.	
38 S.W.	.....	.....	82 H.	Ditto up to limits of survey.
Total ...	.....	5,823	225H. 262 S.H.	

Indian Atlas sheets (new) in progress.

Atlas sheets—				
13 N.W.	81	1,570	.....	Outline completed; writing in progress.
13 S.E.	110	3,450	.....	Outline completed as far as drawing; writing in progress.
14 N.E.	9	.....	.....	Just commenced.
18 N.E.	.....	.....	12 S. H.	Writing and sand hills finished as far as drawing.
20 S.E.	.....	.....	21 H.	Writing and hills finished as far as drawing.
22 N.E.	.....	4,782	.....	Plate put down for more urgent work.
22 S.E.	15	7,242	.....	Additional outline and writing in progress.
23 N.E.	.....	751	.....	Writing in progress.
23 S.E.	25	1,069	.....	Outline done as far as drawing; writing in progress.
31 N.E.	.....	20	7 S. H.	Small portion of survey finished.
32 N.W.	.....	1,418	128 S. H.	Heavy sheet. Sand hills in progress.
36 N.E.	40	3,430	10 H.	Outline and writing of new survey finished; hills in progress.
37 S.E.	44	2,651	14 H.	Hills in progress.

PROGRESS REPORT OF THE ENGRAVING OFFICE FROM 1st OCTOBER 1882 TO 30th SEPTEMBER 1883.

Indian Atlas sheets (new) in progress—concluded.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
Atlas sheets—	Sq. in.	Letters cut.	Sq. in.	
38 N.W.	207	2,624	.....	New border and scale cut; writing in progress.
38 N.E.	.....	.....	.....	Slight corrections to outline.
38 S.W.	231	2,046	.....	New border and scale cut; writing in progress.
38 S.E.	70	432	.....	Outline of fresh survey in progress.
39 N.W.	231	.....	.....	Outline just finished; writing about to be gone on with.
39 N.E.	33	.....	.....	Outline in progress.
39 S.E.	100	.....	.....	Projected; border and scale cut; outline in progress.
40 N.E.	126	348	.....	Outline done as far as drawing; writing in progress.
40 S.E.	42	.....	.....	Outline done as far as drawing.
48 N.E.	12	84	.....	Fresh survey about to be put in hand.
48 S.E.	15	4,418	.....	Corrections and additions to outline done; writing in progress.
49 N.E.	100	.....	.....	
61 N.E.	208	.....	.....	Projected; border and scale cut; new outline commenced.
61 S.E.	231	.....	.....	Projected; border, scale and new outline cut.
67 N.E.	.....	.....	38 H.	Hills in progress.
67 S.W.	.....	154	.....	Title cut; corrections to outline and writing done.
69 N.E.	12	1,193	.....	Done as far as drawing.
69 S.E.	72	769	40 H.	Fresh drawing of new survey; outline in hand.
76 N.W.	.....	96	.....	Projected; border and outside figures cut; outline just commenced.
76 N.E.	.....	9,600	.....	Plate well advanced; in progress.
76 S.W.	.....	888	.....	Writing in progress.
76 S.E.	.....	8,812	.....	Slight corrections to outline; writing done; lakes shaded; hills about to be commenced.
77 N.W.	231	8,934	.....	Projected; border, scale, outside figures and district names cut.
77 S.E.	.....	7,524	.....	Slight corrections to outline; writing well advanced.
78 N.E.	.....	974	.....	
131 S.E.	45	.....	.....	Waiting drawing for hills.
Total ...	2,290	75,279	123H. 147 S.H.	

Additions and corrections to the Indian Atlas sheets.

10 N.E.	.....	.....	.....	Slight corrections to writing done.
23 N.W.	.....	187	.....	Additional writing and slight corrections done.
31 N.W.	.....	249	.....	
35 S.E.	37	852	26 H.	Heavy additions of new survey engraved, corrections to outline, writing and district names done.
53 N.E.	.....	40	.....	Additional railways and names cut.
53 S.E.	.....	27	.....	
66 N.W.	.....	.....	.....	Slight corrections to outline and writing done.
66 S.E.	.....	.....	.....	
77 N.E.	.....	1,755	.....	Corrections and additions done.
125 N.E.	.....	.....	.....	Heavy corrections and additions to boundaries done.
129 N.W.	.....	103	1 H.	Heavy additions, skeleton outline and hills, done.
131 N.E.	95	.....	.....	New plate of recent survey, outline in hand.
Total ...	132	3,213	27 H.	

PROGRESS REPORT OF THE ENGRAVING OFFICE FROM 1st OCTOBER 1882 TO 30TH SEPTEMBER 1883.

Repairs and additions to old plates of the Indian Atlas.

Title of Map.	Outline.	Writing.	Hills and sand.	Remarks showing progress.
Atlas sheets—	Sq. in.	Letters cut.	Sq. in.	
47	.....	.....	80 H.	Hills being repaired, in progress.
54	.....	52	16 H.	Heavy additions.
55	.....	891	19 H.	Slight corrections to outline and writing; hills etched on portion of new survey, and adjoining hills touched up.
64	.....	1,568	.....	Additional writing cut.
79	.....	.....	58 H.	Portion of hills repaired and finished.
102	.....	142	.....	Additional outline and writing cut.
103	.....	50	.....	Heavy corrections and additions done; additional railways cut.
107	.....	.....	162 H.	Hills repaired.
108	.....	.....	103 H.	Hills engraved on portion of new survey, finished.
109	.....	.....	12 H.	Hills repaired and finished.
111	.....	160	.....	Additional railway, degree figures, and part of border cut.
112	.....	.....	.....	Railways corrected and added to.
114	.....	56	.....	Slight additions done.
121	.....	.....	.....	Slight corrections and additions to outline and writing done.
Total ...	.....	2,919	450 H.	

New plates projected, borders cut, &c.

4 Four-quarters ...	.....	.....	.....	Projected.
5 N.E.	.....	.....	.....	Projected.
24 N.E.	.....	.....	.....	Ditto and border cut.
24 S.E.	.....	.....	.....	Ditto and border cut.
39 S.W.	.....	.....	.....	Projected.
40 N.W. and S.W. ...	.....	.....	.....	New scale cut.
49 S.E.	.....	.....	.....	Border cut.
50 Four quarters ...	.....	.....	.....	New scales cut.
57 N.W., S.W., and S.E.	.....	1,704	.....	New scales and outside figures cut.
61 N.W. and S.W. ...	.....	.....	.....	Projected and new borders cut.
62 Four quarters ...	.....	1,405	.....	Outside figures cut.
68 Ditto ...	.....	.....	.....	Projected and borders cut.
76 N.W.	.....	.....	.....	New scale cut.
80 Four quarters ...	.....	2,217	.....	Outside figures cut.
94 Ditto ...	.....	.....	.....	New scales cut.
103 Ditto ...	.....	.....	.....	Projected and new borders cut.
114 Ditto ...	.....	492	.....	Projected, new borders and out side figures cut.
115 Ditto ...	.....	320	.....	Projected, new borders and out side figures cut.
Total ...	.....	6,138	.....	

Abstract of work completed and in progress.

Engraving.

	Plates.
Atlas sheets completed	7
Ditto in progress in various stages	39
General maps, plans, &c.	90
Repairs, corrections, and additions ...	26
Projections engraved, borders cut, &c.	49
Total ...	211

Copper-plate printing.

Impressions taken	13,329
Proofs pulled	1,503
Transfers pulled	282
Total ...	15,114

Steel-facing.

	Plates.
Double elephant plates, steel-faced ...	24
Ditto ditto, re-steeled ...	19
Quarter plates, steel faced ...	78
Ditto, re-steeled ...	36
Miscellaneous plates, steel-faced ...	85
Ditto, re-steeled ...	31
Total ...	273

Square inches of hill etching ...	1,607
Ditto of jungle etched ...	312
Ditto of outline	2,844
Number of letters engraved	225,771

C. W. COARD,
Superintendent, Engraving Office.

C. STRAHAN, *Major*, R.E.,
Assistant Surveyor-General,
In charge Engraving Office.

Tabulated Statement of the principal records prepared in the several Executive Offices of the Revenue Branch for the year ending 30th September 1883.

Province and District.	Survey party.	Mapping.						Traverses.		Field Books.		Area Books.		For Settlement Department.		
		Original field sections.	Cadastral 16-inch sheets.	Sheets, 4-inch = 1 mile.	Quarter sheets, 2 inch = 1 mile, 15′ × 7½′.	Index maps.	Triangulation charts.	Main circuit with azimuth computations.	Village or sub-circuit.	Main circuit.	Village or sub-circuit.	Villages.	Fields.	Sheets or traces.	Village areas or khasrahs.	
North-West Provinces.							Cadastral Surveys.									
Ballia	No. 4	346	340	4	15	.....	.....	.....	1	.....	3	298	163,616	.....	.....	
Benares	Ditto	658(*a*)	658(*a*)	.....	3	.....	.....	1 Tr. 1 Az.	3	1	10	852(*a*)	313,742(*a*)	.....	.....	(*a*) Inclusive of 1 village of district Shahabad surveyed on 16″ scale.
Mirzapur...	No. 5	.....	488 (old work). 886 (new work).	.....	.....	30	.....	4(*b*)	7(*b*)	4(*b*)	14(*b*)	.....	.....	.....	621	(*b*) Old work.
Tarai	Ditto	.....	37	9	.....	.....	.....	.....	1	.....	2	.....	.....	23	23	
Gorakhpur	Ditto	563(*c*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(*c*) Plotted for 16″ survey in Gorakhpur.
British Burma.																
Hanthawaddy ... Pegu ... ... Tharrawaddy ... Prome	No. 2 No. 7	807	807 959	.....	15 19(*d*)	3	.....	3 1	3 1	3 1	4 1	384	650,560	.....	.....	(*d*) These 19 sections contain the entire district of Tharrawaddy surveyed by this party.
Bassein	No. 8	567	567	.....	.....	1	.....	3	3	3	5	.....	.....	.....	.....	
Henzada	Ditto	169	139	.....	12	.....	.....	.....	.....	.....	.....	266	531,194	.....	.....	
Punjab.							Village and Topographical Surveys.									
Murree and Kahuta Hills.	No. 1	.....	.....	34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Hissar	Ditto	48 on 2″	.....	.....	26(*e*)	.....	.....	1	3	1	3	.....	.....	.....	.....	(*e*) 2-inch maps in duplicate for reduction and reproduction.
Bombay.																
Thana	No. 10	21 on 4″ 1 (portion) on 2″	.....	27	6,30′×15′	1	1	1	1	1	4	.....	.....	.....	.....	
N.-W. Provinces.																
Bulandshahr, Aligarh, and Eta.	No. 3	93 on 2″	.....	49	22 fair 26 exaggerated.	4 Atlas reductions. 1 Tr. of ditto 1 Contour map of height.	.....	2 Trav. 1 Az.	3 Vil. block 2 River (of 4″)	1	5	.....	.....	.....	.....	
Bengal.																
Shahabad	No. 4	16 on 4″	.....	16	.....	.....	.....	1 Az.	1	.....	2	.....	.....	.....	.....	
Sarun	Ditto	13 on 4″	.....	13	.....	.....	.....	.....	1	.....	2	.....	.....	.....	.....	
Hooghly, 24-Pergunnahs, and Midnapur.	No. 6	142 on 16″ 75 on 6″	115 in one minute sec. on 16″, 4 on 8″ 5 on 6″	16	2 on 1″	1	1 on 100 chains = 1-inch.	2 Vols. main and minor tr. 1 Vol. az. 2 Hor. angles 1 Sec. triangles, &c. 1 Rectr. co-ordinates of G. T. S.	.....	2	9	.....	.....	.....	.....	
Ratnaghari, Satara, Sholapur.	No. 11	25	.....	.....	12	1	1 of sheets 89 and 90.	.....	1 of sheets 89 and 90.	.....	1 of sheets 89 and 90.	.....	.....	.....	.....	

Revenue Survey Branch Office,
Calcutta, the 1st October 1883.

J. SCONCE, *Col.*,
Deputy Surveyor-General, in charge Revenue Branch.

Extract from Report of MAJOR J. WATERHOUSE, *Assistant Surveyor-General, in charge Lithographic Office, Survey of India Department,—season* 1882-83.

MAJOR R. V. RIDDELL, R.E., was in charge of the office till the 19th April, when I took over charge on that officer's departure for Bombay.

The annexed statements L1, L2, L3, and L4 show the amount and value of the departmental, extra-departmental, and type work done during the year; and the progress of the office will be readily seen from the abstract given below, in which the out-turn of the year is compared with that of the previous year :—

	1881-82.			1882-83.		
	Number of subjects.	Number of copies printed.	Value.	Number of subjects.	Number of copies printed.	Value.
			Rs.			Rs.
Departmental maps, &c. ...	211	26,667	19,631	154	21,871	23,536
Ditto forms ...	53	40,810	4,615	27	14,216	2,294
Extra-departmental maps, &c. ...	471	196,366	22,767	346	121,353	20,114
Type work	3,198	323,817	9,530	1,388	249,085	8,317

As will be seen from the above, the work generally shows an increase, which is particularly noticeable in work done for other departments, and in departmental forms printed from stone, which have nearly trebled. The number of items set up in type is also considerably more than doubled, and there is a large increase in the number of impressions from type.

Among the new departmental maps drawn, there is nothing particularly worthy of note, the principal items being index maps and a continuation of the 1-inch sheets of the Oudh Revenue Surveys. A contour map has been commenced on the basis of the 32-mile map of India. Five new district maps on the scale of four miles to the inch have been prepared by transfer from the engraved copper-plates; 50 district and provincial maps, foolscap size, on scales of 8 and 16 miles to the inch have been prepared, but not yet printed off.

The extra departmental work has been of the usual miscellaneous character, and the only important items are an Irrigation Map of the North-Western Provinces and Oudh, in four sheets, on the scale of eight miles = 1 inch, printed in three colours, and a Rainfall Chart of India on the scale of 64 miles = 1 inch, which was not finished at the end of the period under review.

The only novelty in the work of the office has been the introduction of a machine for making rubber stamps. It was taken over from the Master of the Mint, and has proved useful in making up stamps for office and departmental use.

Mr. H. L. Lepage, Head Assistant, having obtained furlough for one year from 24th July 1883, Mr. Alfred G. Palmer of the Engraving Office was appointed to officiate for him, and has performed his duties satisfactorily. Mr. J. Watson has remained in charge of the Printing Department throughout the year, and performed his work with his usual zeal and skill. Mr. DePyvah, in charge of the Type Department, has also worked very well, and made good way against the largely increased demands in that branch. The conduct of the native clerks and draftsmen has been satisfactory.

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC OFFICE, SURVEY OF INDIA DEPARTMENT, BETWEEN THE 1st OCTOBER 1882 AND 30th SEPTEMBER 1883.

L. 1.

Work done for the Survey Department.

Description of Maps.		Scale of maps.	Size of each sheet.	Number of sheets.	Number of coloured copies.	Number of uncoloured copies.	Total number of copies printed.	Number of impressions.	Value.	Remarks.
Index Maps.									Rs. A. P.	
New Maps, &c., drawn during the year.										
Index to the standard sheets of the North-West Provinces and Oudh, on the scale of one inch = 4 mile.	Re-transfer made with corrections and additions.	1 inch = 32 miles.	Imperial. ...	1	...	150	150	150	85 0 0	
Index to the standard sheets of the Panjab, on the scale of one inch = 1 mile.	Ditto... ...	Do. do.	Super Royal...	1	...	.....	.....	.....	195 10 7	Not yet printed.
Index to the standard sheets of Assam, on the scale of one inch = 1 mile.	Ditto... ...	Do. do.	½ sheet do.	1	...	.....	.....	.....	84 10 10	Ditto.
Index to the sheets of Bengal, on the scale of one inch = 8 miles.	Ditto... ...	1 inch = 64 miles.	Foolscap ...	1	...	200	200	200	43 2 2	
Index chart of survey of North-eastern Afghanistan, on one inch and half inch scale, to accompany annual report.	Drawn on transfer paper.	1 inch = 16 miles	Ditto ...	1	...	760	760	760	76 3 10	
Index to the sheets of the revenue survey of Oudh and Sindh, on the scale of one inch = 1 mile.	Ditto ...	Various scales	½ sheet do.	2	...	404	404	404	69 13 6	
Index to the sheets of the Rewah and Bundelcund Topographical Survey, on the scale of one inch = 1 mile.	Drawn on stone	Various scales	Ditto ...	1	...	202	202	202	35 15 4	
Index to the sheets of Chota Nagpur Division, on the scale of one inch = 1 mile.	Ditto ...	Various scales	Ditto ...	1	...	202	202	202	44 3 6	
Index maps of District Terai, on the scale of one inch = 1 mile.	Corrections and additions made and colour stones prepared.	1 inch = 8 miles	Foolscap ...	4	512	50	562	1,074	62 11 2	
Reprints.										
Index to the Indian Atlas, on the scale of one inch = 4 miles.	Ditto ...	1 inch = 128 miles	Imperial ...	1	200	512	255	400	82 11 2	
Index maps of Nos. 1, 2, 5, 6, 7, 8, and 9 Topographical Parties of standard sheets, on the scale of 2 inches, 1 inch, ½ inch, and ¼ inch = 1 mile, to accompany annual report.	Ditto ...	Various scales ...	Foolscap ...	6	3,000	200	3,200	9,421	582 8 0	
Index to the survey of South Sylhet and Tipperah Hills, on the scale of one inch = 4 miles, one inch = 2 miles, and two inches = 1 mile, to accompany annual report.	Ditto ...	1 inch = 8 miles	Ditto ...	1	500	50	550	1,574	121 12 1	
Index to the sheets of topographical survey, district Kohat, on the scale of 1 inch = 1 mile, to accompany annual report.	Ditto ...	1 inch = 16 miles	Ditto ...	1	520	50	570	1,610	87 2 2	
Index to the sheets of Baluchistan Survey, on the scale of one inch = 2 miles, and one inch = 4 miles, to accompany annual report.	Ditto ...	1 inch = 32 miles	Ditto ...	1	513	50	563	2,033	98 4 2	
Index to the Indian Atlas showing the state of the engraving to 1st October 1882 of sheets, on the scale of one inch = 4 miles, to accompany annual report.	Ditto ...	1 inch = 256 miles	Ditto ...	1	506	.....	506	1,012	75 9 0	
Index to the sheets of the Mysore Topographical Survey, on the scale of one inch = 1 mile.	.....	Various scales	Ditto ...	1	...	50	50	5	11 6 0	
Index map of No. 4, Revenue Party of sheets on the scale of ¼ inch = 1 mile.	.....	Various scales	Ditto ...	1	...	100	100	100	9 13 0	
Revenue Survey Maps.										
New Maps, &c., drawn during the year.										
Oudh Revenue Survey, sheets, Nos. 121, 135, 136, 151, 154, 176, and 177, second edition.	Drawn on transfer paper.	1 inch = 1 mile.	Double Royal	7	...	.....	.....	.....	4,561 10 11	Not yet printed.
Districts Bijnour and Moradabad, sheet No. 30.	Ditto ...	Do. do.	Ditto ...	1	...	.....	.....	.....	297 7 8	Ditto.
Districts Bijnour, Moradabad, and Terai, sheet No. 46.	Ditto ...	Do. do.	Ditto ...	1	...	.....	.....	.....	636 8 2	Ditto.
Maps, &c., drawn previously, but printed during the present year.										
Oudh Revenue Survey, sheets, Nos. 107, 133, 134, 203, 120, 146, 153, 166, and 178, second edition.	Corrections made	1 inch = 1 mile.	Ditto ...	9	...	2,538	2,538	2,538	2,069 3 9	
District Noncolly, sheet No. 12.	Ditto ...	Do. do.	Ditto ...	1	...	282	282	282	301 0 0	
General Maps.										
North-West Provinces and Oudh	Corrections and additions made	1 inch = 32 miles.	Imperial ...	1	...	205	205	205	56 15 4	
Carried over ...	.....	.....	.....	43	5,833	5,643	11,481	24,943	9,701 6 4	

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC OFFICE, SURVEY OF INDIA DEPARTMENT BETWEEN THE 1st OCTOBER 1882 AND 30th SEPTEMBER 1883.

Work done for the Survey Department—continued.

Description of Maps.	Scale of maps.	Size of each sheet.	Number of sheets.	Number of coloured copies.	Number of uncoloured copies.	Total number of copies printed.	Number of impressions.	Value.	Remarks.
General Maps—*concluded.*								Rs. a. p.	
Brought forward ...	.....	.....	43	5,833	5,645	11,481	21,948	9,701 6 4	
Maps transferred from engraved sheets of the Atlas of India, &c.									
India, No. 7, 9th edition ...	Additions and Corrections made and colour stones prepared	1 inch=128 miles.	Imperial ...	1	110	52	162	492	239 4 10
India, Atlas, quarter sheets Nos. 83 NW. 86 SW, and 72 NW.	Corrections made on stone.	1 inch=4 miles	¼ sheet atlas ...	3	...	606	606	606	257 6 4
Outline map of India in 6 sheets	.....	4 inch=32 miles	Double elephant.	6	...	20	20	120	73 0 0
Indian Atlas, full sheets Nos. 17 and 31.	Corrections and additions made.	1 inch=4 miles	Antiquarian ...	2	...	304	304	304	337 0 7
India	.....	1 inch=96 miles	Atlas ...	1	...	62	62	62	52 4 8
Punjab Provinces	Corrections and additions made.	1 inch=32 miles	Do. ...	1	...	102	102	102	47 0 9
Bengal, Behar, and Chota Nagpur.	Ditto ditto	Ditto ...	Double elephant.	1	...	.....	.....	.....	138 9 0 Not yet printed.
Province of Assam under the jurisdiction of the Chief Commissioner for 1883.	Ditto ditto	Ditto. ...	.....	1	...	.....	.....	.....	44 3 7 Ditto.
Preliminary map of Bombay ...	Corrections and additions made.	Ditto ...	.....	1	...	.....	.....	.....	99 10 3 Ditto.
Contoured sheet No. 5 of the outline map of India.	Contoured lines and corrections made.	Ditto ...	.....	1	...	.....	.....	.....	60 6 0 Ditto.
Maps transferred previously from the engraved sheets, but printed during the present year.									
Indian Atlas, full sheet No. 67 ...	Colour stone prepared.	1 inch=1 mile	Antiquarian ...	1	62	62	124	162	175 12 8
Central Provinces in 2 sections	Corrections, &c., made on stone.	1 inch=16 miles	Double elephant.	2	...	125	125	250	205 6 10
The Provinces of Bengal, Behar, Chota Nagpur, and Orissa, in 4 sections.	Further corrections made, and colour stones prepared.	Ditto ...	Atlas ...	4	155	58	213	4,472	413 10 3
India in 2 sheets without hills ...	Further corrections.	1 inch=64 miles	Double Royal.	2	...	47	47	94	63 1 8
Reprints.									
Indian Atlas, full sheets Nos. 48 and 131.	.....	1 inch=4 miles	Antiquarian ...	2	...	75	75	75	76 5 9
Assam in 7 sheets, sheets Nos. 1, 2, 3, 5, 6, 7, and 8.	.....	1 inch=8 miles	Imperial. ...	7	...	531	531	531	146 9 0
India in 6 sheets, sheets Nos. 1, 2, 3, 4, 5, and 6 (2nd edition).	.....	1 inch=32 miles	Double elephant.	6	...	403	403	403	406 12 6
India, 1877, with hills, additions to 1880, in 2 sheets.	.....	1 inch=64 miles	Double Royal.	2	...	72	72	141	109 9 3
India, No. 2a	.....	1 inch=128 miles	Imperial ...	1	...	152	152	152	32 8 3
The Provinces of Bengal, Behar, Orissa, and Chota Nagpur, in 2 sheets.	.....	1 inch=16 miles	Antiquarian ...	2	...	102	102	204	196 12 8
Eastern and Western Bengal in 16 sheets, sheets Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16.	Corrections and additions made on stone.	1 inch=8 miles	Imperial ...	16	...	1,744	1,744	1,744	1,120 7 9
British Burma, sheets Nos. 3 and 4.	.....	1 inch=4 miles	Antiquarian, and double elephant.	2	...	104	104	104	80 7 4
India shewing the progress of the Imperial survey to 1st October 1883, to accompany annual report.	Corrections, &c., made, and colour stone prepared.	1 inch=128 miles	Imperial ...	1	520	.....	520	2,080	243 2 5
Punjab in 8 sheets, sheets Nos. 1, 2, 3, 4, 5, 6, 7, and 8.	Corrections, &c., made on stone.	1 inch=8 miles	Double elephant.	8	...	816	816	816	663 7 11
Southern Afghanistan, sheet No. 3.	.....	1 inch=4 miles	Antiquarian ...	1	...	50	50	100	76 15 6
District Maps.									
Maps transferred from engraved sheets of the Atlas of India.									
District Bancoorah	Corrections and additions made and colour stone prepared.	1 inch=4 miles	Atlas ...	1	100	100	200	340	162 12 7
,, Rajshahye	Ditto	Ditto ...	Ditto ...	1	102	100	202	301	161 4 1
,, Chittagong	Corrections and additions of hill drawn on stone.	Ditto ...	Ditto ...	2	...	.....	.....	.....	681 9 10 Not yet printed.
,, Naga Hills	Corrections and additions made on stone.	Ditto ...	Ditto ...	1	...	.....	.....	.....	55 5 2 Ditto.
,, Hooghly	Ditto	Ditto ...	Ditto ...	1	...	.....	.....	.....	49 3 0 Ditto.
District maps, &c., transferred and prepared from 8 and 16 mile map of Bengal and 32-mile maps of India.	.....	.....	Foolscap ...	50	...	.....	.....	.....	1,062 9 8 Ditto.
Carried over ...	.....	.....	.....	375	6,837	11,330	18,267	32,639	47,117 14 5

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC OFFICE, SURVEY OF INDIA DEPARTMENT, BETWEEN THE 1st OCTOBER 1882 AND 30TH SEPTEMBER 1883.

Work done for the Survey Department—concluded.

Description of Maps.		Scale of maps.	Size of each sheet.	Number of sheets.	Number of coloured copies.	Number of uncoloured copies.	Total number of copies printed.	Number of impressions.	Value.	Remarks.
District Maps—*concluded.*									Rs. a. p.	
Brought forward ...	.....	.....	.....	374	6,897	11,380	18,267	32,639	17,117 14 5	
Maps, &c., transferred previously from the engraved sheets, but printed during the present year.										
District Khoolna	Further corrections, &c., made and colour stone prepared.	1 inch=4 miles	Atlas	1	152	104	256	409	106 13 0	
,, Raepore	Ditto ditto	Ditto	Antiquarian ...	2	102	100	202	714	107 3 3	
,, Goalpara	Further corrections made.	Ditto	Ditto ...	1	...	152	152	152	107 2 6	
Reprints.										
District Sylhet	.....	1 inch=4 miles	Double Royal	1	...	50	50	50	31 9 3	
,, Sonthal Pergunnahs ...	.....	Ditto ...	Antiquarian ...	1	...	54	54	54	33 4 0	
,, Kamroop	Corrections made	Ditto ...	Atlas	1	...	152	152	152	99 8 1	
,, Cachar	.....	Ditto ...	Double elephant.	1	...	50	50	50	31 5 10	
Plans.										
Calcutta, in 2 sheets	Additions and corrections made.	6 inch=1 mile	Double elephant.	2	...	100	100	510	244 8 9	
Ditto, ditto	Ditto ditto	3 inch=1 mile	Super-royal ...	1	...	204	204	204	45 8 9	
Guide plan of Simla and Jutog ...	.....	4 inch=1 mile	Atlas	1	...	110	110	220	57 45 3	
Total ...	.....	.....	.....	185	7,141	12,816	19,957	35,233	18,422 2 6	
Miscellaneous maps, &c.	.....	.....	.....	25	...	.....	7,910	3,004	3,208 12 3	
Departmental forms	.....	.....	Items	33	...	.....	40,510	36,169	4,615 15 7	
Grand Total ...	.....	.....	.....	203	7,141	12,816	67,477	75,322	26,246 4 4	

L. 2.

Work done for other Departments.

Names of Departments	Number of maps.	Number of sheets.	Number of sheets coloured.	Number of sheets uncoloured.	Number of copies printed.	Number of impressions.	Value.
							Rs. a. p.
Foreign Department	45	49	.....	49	3,980	3,038	1,470 14 4
Military Department	90	90	.....	90	36,279	6,513	952 15 9
Revenue and Agricultural Department	12	12	1	11	4,894	4,018	966 10 3
Telegraph Department	11	11	.....	11	2,840	3,696	570 11 6
Bengal Secretariat	26	26	8	18	13,934	9,455	1,213 9 1
Sanitary Commissioner with the Government of India ...	2	2	2	.....	1,726	3,041	515 4 1
Quartermaster-General	20	21	.....	21	6,215	6,107	1,234 5 5
Meteorological Reporter to the Governments of India and Bengal	19	19	4	15	9,695	6,758	1,790 9 3
Archæological Survey of India	58	58	.....	58	33,488	17,888	2,488 11 4
Geological Survey of India	6	6	1	5	3,938	6,179	1,441 4 11
North-West Provinces *Gazetteer*	4	4	.....	4	2,131	2,131	271 13 6
Public Works Department, Government of India ...	1	1	.....	1	62	62	34 14 7
Ditto ditto, ditto of Bengal ...	8	8	.....	8	832	526	538 7 1
Ditto ditto, ditto of North-West Provinces	4	4	4	.....	10	426	513 2 4
Punjab Government	10	10	5	5	5,108	6,103	1,103 7 10
Office of Deputy Superintendent, Census Operations in Bengal	5	5	4	1	5,345	9,615	910 0 5
Office of Deputy Superintendent, Census Operations in Central Provinces	6	6	1	5	3,022	2,028	505 1 2
Miscellaneous drawings	101	101	9	92	63,371	29,661	4,317 12 0
Maps, &c., drawn, but not printed	37	38	3	35	.....	.....	1,462 2 8
Total ...	465	471	42	429	196,386	117,504	22,767 12 5

STATEMENT OF WORK DONE BY THE LITHOGRAPHIC OFFICE, SURVEY OF INDIA DEPARTMENT, BETWEEN THE 1st OCTOBER 1882 AND 30TH SEPTEMBER 1883.

L. 3.

Statement of Type-work, exclusive of transfers, &c., already included in the cost of the several lithographed maps, &c.

Subject.	Items.	No. of copies.	No. of impressions.	Value. Rs.	A.	P.
Circular Orders	31	4,575	6,301	244	14	0
Memorandum, &c.	510	251,383	357,035	5,306	6	0
Forms, &c., for Survey Department	40	47,720	93,210	1,333	6	0
Transfers of headings, foot-notes, references of published maps, for Photographic Office	2,617	20,159	20,159	3,009	0	0
Rubber stamps made for Survey Department	.....	.....	.....	135	15	0
Total	3,198	323,817	481,705	11,034	9	0
Deduct value of transfers, &c., already included in the cost of several lithographic maps	.....	.....	.....	1,504	8	0
Balance	3,198	323,817	481,705	9,530	1	0

L. 4.

General Abstract of Out-turn and Value of Work performed.

Description of Maps.	No. of sheets.	No. of copies.	No. of impressions.	Value. Rs.	A.	P.
Departmental Work.						
General and district maps, &c.	83	7,907	12,476	6,238	5	10
Index maps	21	8,456	18,423	1,494	3	1
Revenue survey maps, scale 1 inch = 1 mile	10	2,820	2,820	2,371	3	9
Plans	4	474	1,064	348	1	2
Miscellaneous maps, &c.	25	7,010	4,498	1,208	12	3
Departmental forms ... Items	53	40,810	36,150	4,615	15	7
Maps, &c., drawn, but not printed	69	.....	.....	7,970	4	8
Total	264	67,477	75,529	24,246	14	4
Work done for other departments	471	196,366	117,504	22,767	12	5
Total of drawing and printing in lithographic office	735	263,843	193,033	47,014	10	9
Work done in type department ... Items	3,198	323,817	481,705	9,530	1	0
Total value	.....	.....	.....	56,544	11	9

Statement of Expenditure.

	Rs.	A.	P.
Establishment	30,369	14	2
Contingent charges	4,854	10	3
Total	35,224	8	6

SURVEY OF INDIA DEPARTMENT,
LITHOGRAPHIC OFFICE,
Calcutta, the 30th January 1884.

J. WATERHOUSE, *Major*,
Assistant Surveyor-General,
In charge.

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Extract from the Report of Major J. WATERHOUSE, R.E., *Assistant Surveyor-General, in charge Photographic Office, season* 1882-83.

I HAVE the honour to submit the usual tabular statements of work done, expenditure, &c., in this branch of the Survey of India offices, during the survey year from 1st October 1882 to 30th September 1883.

A. Abstract of work performed during 1882-83.

B. Comparative statement of out-turn of 1881-82 and 1882-83.

C. Statement shewing the value of work done for other departments.

D. Statement of expenditure and value of work done.

OUT-TURN.—(*Ordinary*). Although the number of original departmental and extra departmental maps, &c., received for reproduction was not quite so large as last year, the work generally shews an increase all through, particularly in the zinc-printing section, the number of press pulls being 30,937 more than last year.

The work received in the office during the year has been of the usual miscellaneous character, and there has been nothing to call for special remark.

CADASTRAL.—The number of sheets of cadastral maps reproduced during the year was 5,113, or 132 more than last year; of these, 129,369 copies have been printed off, representing a money value of Rs. 75,041. Owing to the increasing use of zincography from transfer tracings, the number of negatives taken was less than last year, but the number of press-pulls—each representing one cadastral sheet—was 19,397 more than last year.

As the cadastral work appeared likely to increase in consequence of the establishment of two new parties, the sanction of Government was obtained to the house, No. 2, Wood Street being taken for the office on a lease for three years, from 16th June 1883. The greater part of the cadastral printing establishment was moved into it, and the additional space so gained has been a great advantage, as the space in No. 1, Wood Street was becoming very crowded. The office will now be able to meet all demands upon it until the new buildings are ready. As the whole of No. 2, Wood Street was not immediately required, the upper floor has been let for the cold weather.

EXPENDITURE.—As will be seen from table D, the expenditure of the office, including establishment and stores, has been Rs. 97,436, against Rs. 93,146 of the previous year. The value of work done for other departments, for which credit is taken at the usual scale of rates, has been Rs. 22,070; while other receipts bring the total earnings of the office to Rs. 1,43,699, shewing a profit of Rs. 46,263.

PERSONNEL.—There have not been many changes in the personnel of the office during the year. Mr. W. E. Batho was appointed Head Assistant after two months' probation, on 1st April 1883, but very shortly afterwards he fell ill and died of abscess of the liver on the 20th June 1883. His loss is very greatly to be regretted, as he promised to be a most useful and efficient assistant. Arrangements have been made to fill his place by the appointment of a Mr. H. Haward, from England. He is expected to arrive immediately, and will take charge of the special photo-mechanical printing section. In order to meet the demands for special work for the Exhibition and otherwise, Mr. A. E. Caddy was re-appointed to the office temporarily as photographer and special assistant from the 9th August; but he did his work so inefficiently, that I had to dispense with his services early in October. His place was filled temporarily, pending the arrival of Mr. Haward, by Mr. A. W. Turner, who has proved himself a very useful assistant, his knowledge of pigment-printing being specially valuable.

Mr. Watson having continued on deputation as head printer in the lithographic office, Mr. E. A. LeFranc has been in charge of the cadastral zinc-printing section, and additional strength has been given to this branch by the appointment, from 1st March 1883, of Mr. B. Wilson, as assistant zincographer, officiating in the post of head printer in the lithographic office.

PROCESSES.—There have been few or no changes of importance in the processes used in the office. In the negative section, the system of intensifying with a solution of hyposulphite of soda and ammonia, as described in last year's report, has been successfully used throughout the year, and we have now entirely done away with the hydrosulphate of ammonia. The only objection to this intensifying solution is the tenderness it gives the film; but to prevent this, it has been found an advantage to coat the glass plates with a preliminary substratum of india-rubber in benzole, instead of the usual albumen substratum.

In the photographic transfer printing section, several experiments have been made with the object of obtaining grained transfers of half-tone subjects. Some results obtained were fairly successful, but the difficulties connected with printing such delicate subjects from zinc or stone seem likely to prevent the general adoption of these methods, which at best give results very much inferior in beauty to collotype or heliogravure.

Heliogravure.—This process has progressed fairly steadily throughout the year, and seven plates have been turned out. These include four plates for the Geological Survey, an outline map of Simla and Jutog, and a view of Kin-chin-jinga, for the illustration of last year's annual report. Among the plates in hand, is one of the award certificate for the Calcutta International Exhibition, which has been reproduced with fair success by Mr. Turner from a very delicate Indian-ink drawing. There is also a plate for the Superintendent of the Geological Survey of a piece of gneissose rock, photographed from nature. The results thus obtained are sufficient to prove the utility of the process for the reproduction of this class of work.

The details of the process are unchanged from last year, except that we have found Rangoon oil to be a good medium for ensuring the stripping off of the sensitised gelatine tissue from the glass. Mr. Turner has, however, been very successful in stripping the films from glasses rubbed over with French chalk, as practised at Vienna.

Asphaltum Processes.—During the year, I have given a good deal of attention and study to the asphaltum processes as applied to photo-zincography and photo-engraving, but have not been able as yet to work out any practical process suitable for the class of work we have to deal with.

B.

Comparative Statement of the out-turn of 1882-83 *with that of the previous year.*

	Ordinary Work.				Cadastral Maps.			
	1st October 1882 to 30th September 1883.	1st October 1881 to 30th September 1882.	Difference.	Difference in square inches.	1st October 1882 to 30th September 1883.	1st October 1881 to 30th September 1882.	Difference.	Difference in square inches.
Originals	1,152	1,260	—108	.....	5,113	4,981	+132	.....
Negatives	2,040	1,848	+192	.....	3,462	3,624	—162	.....
Ditto, square inches	5,50,631	6,07,890	.....	—57,259	25,58,816	27,83,232	.....	—2,24,416
Photographic transfers	1,937	1,818	+119	.....	3,629	3,653	—24	.....
Ditto, square inches ...	5,58,180	6,06,254	.....	—47,374	23,67,046	25,07,040	.....	—1,39,994
Silver prints	584	533	+51	.....	.....	.....	.....	.....
Ditto, square inches ...	1,41,724	59,792	.....	+81,932	.....	.....	.....	.....
Transfer to zinc (number of plates)	977	800	+177	.....	5,174	5,000	+174	.....
Number of pulls	1,52,936	99,047	+53,937	.....	1,29,369	1,09,990	+19,379	.....
Ditto of printed sheets (single)	3,91,894	1,25,218	+2,66,676	.....	1,29,369	1,09,990	+19,379	.....
Ditto ditto (combined) ...	2,34,785	1,67,329	+1,79,456	.....	58,344	49,579	+8,765	.....
Proofs	1,401	1,366	+35	.....	5,027	4,753	+274	.....
Transfers	1,174	1,089	+85	.....	5,214	4,922	+292	.....

C.

Statement shewing the Amount and Value of the work done for other departments and despatched between 1st October 1882 *and* 30th September 1883.

Names of Departments.	Number of sections.	Number of negatives.	Number of pulls.	Number of copies.	Number of silver prints, &c.	Amount.
						Rs. A. P.
Asiatic Society, Bengal	25	6	553	1,592	.....	152 14 3
Adjutant-General in India	1	4	25	25	.....	74 0 9
Board of Revenue, North-West Provinces	2	12	750	376	.....	353 6 0
Calcutta Exhibition Committee	1	3	505	500	.....	135 13 0
Chief Engineer, Bengal Public Works Department, Irrigation	10	37	935	940	.....	827 6 6
Director-General of the Archæological Survey	22	6	2,770	11,031	.....	454 8 6
Ditto of Telegraphs in India	23	6	6,500	57,500	.....	1,130 15 9
Director of Garrison Instruction in India	1	1	300	300	.....	73 12 2
Engineer to the Corporation for the Town of Calcutta ...	8	9	850	900	.....	216 14 7
Executive Engineer, Quetta Division	1	1	100	100	.....	40 3 0
Government of North-West Provinces and Oudh, Public Works Department, Irrigation	60	60	3,600	43,500	.....	1,216 4 0
Government of India, Public Works Department	47	48	4,700	4,700	.....	977 4 3
Ditto ditto, Military Department	47	23	663	1,523	125	455 6 4
Ditto of Bengal, Public Works Department	19	15	3,300	2,000	.....	1,576 15 10
Ditto ditto, Lower Provinces	40	80	600	600	.....	1,643 7 6
Government Architect, Darjeeling	48	65	1,000	850	.....	1,326 1 5
General, Commanding Meerut Division	8	6	100	100	.....	127 8 0
Inspector-General of Military Works	66	56	6,263	8,020	.....	3,251 5 11
Junior Secretary to the Chief Commissioner, British Burma	36	99	4,063	4,150	.....	2,648 4 1
Manager, Rajputana-Malwa Railway	40	5	2,500	2,500	.....	452 15 9
Ditto, Northern Bengal State Railway	1	4	250	250	.....	137 6 5
Ditto, Tirhoot State Railway	8	12	700	1,400	.....	228 13 2

Statement shewing the Amount and Value of the work done for other departments and despatched between 1*st October* 1882 *and* 30*th September* 1883—concluded.

Names of Departments.	Number of sections.	Number of negatives.	Number of pulls.	Number of copies.	Number of silver prints, &c.	Amount.
						Rs. A. P.
Meteorological Reporter to the Government of India ...	17	11	1,030	6,020	.....	385 2 8
Mint Master, Calcutta	2	2	52	52	2	30 9 5
Ditto, Bombay	1	4	60	60	.....	76 5 0
Ordnance Department	1	1	.....	.....	.....	10 5 0
Officer in charge, *Provincial Gazetteer*, North-West Provinces	2	2	537	532	.....	98 12 0
Port Commissioners	2	3	140	130	.....	159 13 4
Quarter-Master General in India	41	70	8,003	8,357	.....	2,343 5 7
Secretary to the Agent Governor-General, Central India ...	.....	.....	20	20	.....	7 10 9
Secretary to the Defence Committee, Simla	7	28	350	350	.....	359 5 9
Settlement Officer, Hanthawaddy	1	1	403	800	.....	73 1 9
Superintendent, Geological Survey of India	4	3	1,014	1,524	.....	118 13 6
Superintendent, Eden Sanitarium, Darjeeling...	1	.....	300	380	.....	36 14 0
Superintendent, Government Printing, India	3	2	1,127	3,004	.....	260 15 0
Ditto ditto, Bengal	6	4	652	1,986	.....	117 13 6
Superintending Engineer, Central Circle	1	4	29	24	.....	65 5 7
Sanitary Commissioner, Darjeeling	.....	.....	200	209	.....	31 9 0
Lieutenant-General Sir F. Roberts, Commander-in-Chief, Madras	2	8	200	200	.....	174 11 0
Lieutenant-Colonel Cramer Roberts	1	1	.....	.....	14	27 8 0
Total ...	566	705	53,943	166,551	141	22,070 12 0
Cadastral North-West Provinces (Photo-zincographs) ...	1,162	1,162	11,620	6,460	.....	17,864 6 0
Ditto, ditto ditto (Zincographs)	789	.....	7,890	7,060	.....	8,204 13 0
Ditto, British Burma (Photo-zincographs)	1,873	1,873	65,166	25,238	.....	30,148 5 0
Ditto, ditto (Zincographs)	871	.....	23,514	13,194	.....	9,767 14 0
Ditto Bengal (Photo-zincographs)	502	502	18,214	5,012	.....	9,042 10 0
Ditto, ditto (Zincographs)	19	.....	767	767	.....	248 4 0
Total Cadastral ...	5,216	3,537	132,163	57,701	.....	75,266 4 0
Grand Total ...	5,782	4,242	186,116	224,552	141	97,337 0 0

D.

Statement of Expenditure of the Photographic Office, Survey of India Department, during the Survey year, from 1*st October* 1882 *to* 30*th September* 1883.

Normal Establishment.	Rs. A. P.	Rs. A. P.
Superintendent's salary	13,349 7 4	
Establishment	24,222 6 3	
House-rent and taxes	4,478 14 6	
Contingencies	1,282 2 9	
		42,333 4 10
Cadastral Establishment.		
Establishment	24,703 11 2	
House-rent and taxes	183 0 0	
Contingencies	5,196 0 1	
		30,083 11 3
Chemicals and stores received from England	15,365 3 2/4	
Paper received from England	3,382 0 9/6	
		18,747 4 0
Paper and map cloth from the Stationery Office	332 12 0	
Stores and materials received from Stationery Office	132 2 7	
		464 14 7
Stores received from the Mathematical Instrument Office	531 9 0	
Cost of repairs of articles at Mathematical Instrument Office	300 3 0	
Paper received from Lithographic Office	4,701 12 11	
Miscellaneous stores received from other branches	56 4 0	
		5,589 12 11
Work done by the Foundry and Shell Factory, Cossipur and by Government Printing, Bengal	17 5 10	17 5 10
Balance in favour of the Department...	.....	46,263 4 8
Total ...	.....	1,43,599 10 1

Statement shewing the amount credited during the Survey year, from 1*st October* 1882 *to* 30*th September* 1883.

	Rs. A. P.	Rs. A. P.
Topographical and revenue maps and other maps and plans issued to the Surveyor-General's and Deputy Surveyor-General's Offices	42,157 14 3	
Miscellaneous work done for the other branches of the Head-Quarter's Offices	277 3 6	
Miscellaneous extra-departmental maps and plans	22,070 12 0	
		64,485 13 9
Cadastral maps, North-West Provinces ...	26,069 3 0	
Ditto, British Burma	29,906 3 0	
Ditto, Bengal	9,290 14 0	
		75,266 4 0
Old tin and packing cases sent to Mathematical Instrument Office	241 7 0	
		241 7 0
Pure silver recovered from stained paper and collodion films... ..	3,372 4 10	
Sale of unserviceable articles ...	333 12 6	
		3,706 1 4
Total		1,43,599 10 1

Extract from the Narrative Report of W. H. COLE, ESQ., M.A., *Deputy Superintendent, 4th grade, officiating in charge Head-Quarters Office, Trigonometrical Branch, Dehra-Dún, for* 1882-83.

Computing Branch.

THE following cost-table of work done in this branch is similar to that given for last year, in which, however, the average under class 11 was unavoidably incomplete. The percentage now given under this class goes to confirm the necessity for the dissociation (in June 1882) of classes 10 and 11, as well as to shew that the *approximate* percentage for these classes given in last year's report were very near the actual. The decrease percentage observable this year under classes 2 and 5, viewed collectively, is in great measure due to the increment under class 3, consequent on the diversion to a sensible extent of the services of the Senior Assistant, Mr. C. Wood, to the current duties of the office of the Deputy Surveyor-General.

Cost-table in Rupees.

CLASS.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Average per cent.
1. Records, Library	10	113	47	14	27	66	76	31	75	47	60	45	2
2. Computations	431	605	467	469	530	480	483	611	522	699	574	467	23
3. Account, returns, correspondence	406	252	231	336	224	402	579	639	634	613	667	703	20½
4. Supply	41	87	126	89	28	46	60	36	56	20	100	101	3
5. Press copy	155	275	112	54	119	114	215	357	196	133	246	229	8
6. Press proofs	211	184	224	226	155	192	228	176	272	246	187	187	9
7. Charts	8	17	...	9	14	24	26	48	100	108	...	57	1½
8. Station	122	57	23	64	144	112	90	77	104	59	89	27	3½
9. Leave and vacations	215	312	578	479	647	594	270	169	96	98	91	130	13
10. Miscellaneous	137	140	209	206	141	137	193	103	82	145	174	106	6½
11. Meteorology and General Science	407	129	65	166	253	152	217	199	501	224	189	340	10
Total ...	2,142	2,142	2,142	2,142	2,257	2,319	2,457	2,457	2,457	2,457	2,457	2,457	100

The particulars of the work done, indicated in a general manner in the preceding table, are given hereafter in such detail as appears desirable.

CLASS 2.—COMPUTATIONS. (IN DUPLICATE).

Southern Trigon—

Triangles (non-circuit) computed and corrected	195
Ditto feet and miles computed	545
Auxiliary figures computed	72
Ditto examined or corrected	6
Second deductions of λ, L, and A (check traverse)	148
First ditto ditto (auxiliary stations)	228

Sums of squares table for Ceylon Branch Series; E. M. S. table for S.E. Coast Series including therein the Ceylon Branch Series :—

Extra or auxiliary azimuths for entire trigon. Weights of observed angles ...	1
[W x^2]	2 figures.

For supplying data for longitude work (vol. ix), and for secondary triangulation party :—

Reduced compound figure	1
Computed or corrected Secondary triangles	27
Ditto deductions of λ, L, A	26

Observed Latitudes.—Data for determination of latitude, by each star, of 50 stations have been deduced and abstracted from original computations, as last year, and latitudes of 90 stations out of 117 (including re-visits) have been computed. Deduced values of latitude by each star have been abstracted for 20 stations in a table shewing each star's reference,

number, name, Z. D., number of times it was observed, the value of latitude deduced from it, the error on the mean latitude, the mean by each north and south pair, and the difference. or north and south for each pair. Owing to urgent demands in other directions, two pairs of computers were employed on this for only 4½ months.

North-East Quadrilateral.—Assam Valley Triangulation—Examined computations (season 1877-78) of snowy peaks between 88° and 92½° E. longitude, preparatory to arranging for publication of preliminary chart. North-East Longitudinal Series—Adjusted a ray of nine triangles, and corrected nine single deductions of λ, *l*, and *A* of secondary points.

Eastern Sind Series.—Reduction taken up *ab initio* and completed. In addition, the following computations (in duplicate) were made either preliminary to, or consequent upon, the reduction:—

Triangles computed	67
(Real and check also auxiliary) first deductions of latitudes, longitudes, and Azimuths computed	54
(Real and check) second deductions, latitudes, longitudes, and azimuths computed ...	40
Auxiliary figures computed	12

Extra or auxiliary azimuths for entire series (occupied a pair of computers 1¾ month).

Mergui Base.—After general examination, the Bar comparisons and temperature of Bar B were reduced: the former were abstracted and means taken. Equations for determination of the error of compensation of the Compensation bars were formed and solved in accordance with the method described in Chapters VII and VIII of Volume I of the operations, &c. Measured length computed and reduced to mean sea-level. Also computed data "for constructing curves to exhibit the nominal excess of the mean of all the Compensation bars over the standard." (All in duplicate.)

Eastern Frontier Series, Season 1881-82.—Secondary work:—Computed 13 triangles and compared miles of 40 triangles, 76 single deductions of λ. *l*, and A, and 78 deductions of height; also computed extra or auxiliary azimuths for preliminary chart of seasons 1879-82. (All in duplicate.)

Computations for Colonels Branfill and Campbell, and for Major Heavside.—These computations are in connection with the Eastern Frontier Series operations in season 1881-82, including the Mergui base, and with the longitude operations occupied a pair of computors for 3½ months.

Miscellaneous and Incidental computations.—(In duplicate):—

Jodhpore Series, Abu Triangulation.—Computed two traverses, fitted in and computed 55 triangles, and computed 29 single deductions of λ. *l*. and A.

Aden Triangulations.—Deduced means of vertical angles and level corrections, and computed 21 deductions of heights.

Survey detachment in Kashmir.—Examined angle-books and engaged with experimental computation of angles observed by Sub-Surveyor Ahmad Ali.

Hazára Triangulations.—Computed from rectangular co-ordinates the λ, *l* of 24 points.

Azimuth by altitude of two stars (observed by Mr. Bond), computed for laying down meridian line for pillar of new observatory for large photo-heliograph.

Computed d ⊿ λ, d ⊿ *l*, d ⊿ A for arcs Kaliánpur-Kurrachee, and Kaliánpur-Mergui; also the E. M. S. of side, λ, *l*, A of the same arcs.

Examined Mr. W. G. Beverley's computation of heights on the Bombay Longitudinal Series re-observed by him in 1881-82. (Occupied a pair of computers ½ a month.)

Class 3.—Accounts, Returns, Correspondence.

As mentioned in last year's report, a considerable portion of the work embraced in this class is of a purely professional nature; in addition, the current work of the office of the Deputy Surveyor-General, Trigonometrical Branch, has had to be carried on since the middle of February last.

Class 4.—Supply.

Over 40 officers have been supplied with data of various descriptions: 1,050 despatches of maps, charts, books, and forms have been made during the year.

Class 5.—Press Copy.

Southern Trigon.—Reductions of two figures abstracted, and those of five figures compared. Tabulated and compared tables of geodetic elements of traverse stations. Descriptions of principal stations (for publication) have been proceeded with; but owing to the limited power that can be employed on this work, it still remains a long way from completion. Prepared (single copy of) latitude, longitude, and azimuth table. Transcribed tables of μ ϕ for entire trigon, and of b. c. for part.

Electro Longitude, or Volume IX.—Checked references in appendices and numerical quantities in several tables. Also prepared and compared contents errata and addenda tables.

N.-E. Quadrilateral, Volumes VII and VIII.—The introduction to the Assam Longitudinal Series was completed for the Principal work, and that for the Secondary work was also completed, but still stands unpublished, awaiting such additional information as officers who took part in the operations may be able to supply.

N.-E. Quadrilateral, Synoptical Volumes XIV to XX.—Completed in respect to preface, contents, errata *et* addenda, and reference tables.

Synoptical Volume of Assam Longitudinal Series.—Azimuth table re-compared: re-arrangement of points in square degrees proceeded with in substitution of co-ordinate list.

Letter-press completed—For preliminary charts of Eastern Sind Series (1880-81), Eastern Frontier Series (1879-82), Assam Longitudinal Series (seasons 1852-78), and Aden Triangulation.

Eastern Sind Series.—Prepared numerical and alphabetical lists and descriptions of stations; also finished the abstracting and comparing of observed angles, and reduction of figures.

Jodhpore Series.—Azimuth table and co-ordinate lists finally disposed of (*i.e.*, prepared and compared) for publication.

Abu Triangulation.—Prepared triangles, azimuth table, and co-ordinate lists.

Northern Afghanistan Synoptical Volume.—Transcribed over 600 triangles, and examined letter-press generally.

Miscellaneous.—Route book; revised and corrected polymetrical tables in part. Spirit-leveled pamphlets Southern India; examined and corrected for reprint. New edition of office (general and special) forms settled upon, and indent form including them prepared, &c., &c.

South Párasnáth and South Malúncha Series.—Account of the reduction of these two series prepared, and beginning made with the introduction to the former series.

Class 7.—Charts.

Final	Compared East Calcutta, Eastern Frontier, and Brahmaputra Series. Owing to number of mistakes, examined against letter-press South Afghanistan Triangulation chart; [chart needs re-preparation.]
Preliminary	Corrections examined in Assam Valley Triangulation, season 1876-78. Compared Aden Triangulation.

Class 8.—Stations.

A table similar to that given for the first time last year is furnished, so that an adequate idea may be formed from it of the extent and character of the work which is imposed on this office by the important duty of protecting our principal stations, and where these are either too far distant, or very scanty—as in the Irrawaddy delta in British Burma, and along the east coast of the peninsula in the Cuttack, Pooree, and other districts—our secondary stations also.

Number of stations.	Number of districts in which stations occur.	Number of lists in which stations included.	Duplicate (*i.e.* finally disposed of) lists.		Number of lists sent out from this office during the current year.		Number of local officers who have—		Number of stations proceeded during the year.	Number of bills audited and passed.	Total cost.	Average cost per station for repairs.	Number of letters, dockets, &c. issued.
			Number of lists.	Number of stations included.	New.	Supplementary.	Reported during the year.	Not reported during the year.					
											Rs.	Rs. A.	
3,535	333	317	310	3,458	.....	.....	239	78	83	225	3,906	4 3	About 400*

* Note for "about 500" given in this column in last year's report read "about 400."

It will be seen from the preceding that 63 new stations have been added during the year under report; that the number of stations repaired is 930 (against 760 last year); and that the average cost per station is Rs. 4-3 (against Rs. 4-8 last year). The number of officers who have not reported has unfortunately increased from 54 to 78, but as it is in contemplation to arrange for sending out reminders to those who failed to do so, it is to be hoped the figures next year will shew a very much smaller number of deficiencies.

Class 10.—Miscellaneous.

Volumes of the G. T. Survey.—Volume VIII, pages examined and collated; and this together with volume IX despatched to Calcutta for binding. Distribution lists, presentation labels, and receipts, prepared for issue (through Surveyor-General's Office, Calcutta) of volumes VII, VIII, IX. Synoptical volumes:—Pages examined and collated for XIV to XVIII, and despatched to Roorkee for binding. Examined after binding, prepared distribution lists, presentation labels, and receipts for XIV, XV and XVI, and issued these volumes.

Examination papers.—The workings of six candidates for the junior branch of the Survey Department examined.

Time observations.—Forty five sets of observations to the sun (on 15 days) for local time taken and reduced, and the rating of chronometers and clocks done as usual.

Annual report of Eastern Frontier Series for 1881-82, *transcribed; and list of Burmese names occurring in Mergui Base-line book, transliterated.*

Mr. Assistant Surveyor Beechey (appointed to the Department in December 1882) and native surveyors Moung Shoay Gyoke and Ahmad Ali received professional instruction.

Sind and Cutch survey coterminous sheets examined with a view to determining the most satisfactory method of establishing a connection between the two surveys. Devised and prepared forms for calculation of azimuth and distance from λ L as data to be employed with Tables VI and XXXVI of the auxiliary tables to facilitate the calculation of the Survey Department of India; checked estimates for construction of new observatory for the large photo-heliograph. Mr. Bond made an elaborate examination of the records and maps of the Dehra-Dun and Sewalik Survey, which was on the scale of 4 miles = 1 inch, with the object of ascertaining to what extent the work already done could be utilized in the 16-inch survey about to be undertaken for the re-settlement of the Dún. Besides preparing a report he plotted a large quantity of information on a set of maps, and both were made over to the officer in charge of the operations.

* * * * * * * *

Class 11.—Meteorolgyy and General Science.

Meteorological observations.—No change has been made in these on the procedure of former years. Thus the results of the observations taken at Dehra twice on every day, have continued to be supplied to the Meteorological Reporter to the Government of the North-West Provinces and Oudh; while daily weather telegrams and anemograms for Mussooree for over six months, as well as anemograms for Dehra for the twelve month, have been furnished to the Meteorological Reporter to the Government of India. The usual tables of monthly results, and of the mean velocity of the winds at Dehra are appended. Another twelve months' observations of deep-sunk earth thermometers have been added, but the data is still incomplete for a detailed discussion of the results. The table of monthly means given in last year's report has therefore been simply extended to the end of 1883, from which it will be seen that the mean minimum temperature attained at the several depths has invariably been less in 1883 than in 1882:—

Mean Monthly Readings of Deep-sunk Earth Thermometers.

Year and Month.	Depths in feet of thermometer bulbs below surface of ground.					Thermometer in shade.
	25·6	12·3	6·4	3·2	1·1	
1881.						
June	75°·55	74°·87	80°·68	81°·93	89°·16	87°·68
July	75°·90	76°·47	81°·01	83°·29	84°·14	82°·54
August	76°·02	77°·88	80°·75	82°·03	81°·55	81°·00
September	76°·07	76°·93	81°·24	82°·16	83°·19	82°·86
October	76°·69	75°·86	80°·35	79°·97	77°·91	82°·72
November	76°·98	77°·71	76°·80	72°·79	67°·81	76°·23
December	76°·71	74°·99	70°·58	65°·63	60°·72	71°·19
1882.						
January	75°·94	73°·35	67°·17	62°·57	55°·91	66°·71
February	75°·13	70°·79	66°·06	62°·31	59°·41	68°·51
March	74°·52	70°·47	67°·75	67°·61	69°·30	81°·36
April	74°·11	71°·70	72°·29	75°·49	78°·88	88°·72
May	73°·97	73°·57	76°·47	80°·66	84°·09	91°·04
June	74°·05	76°·23	80°·01	84°·77	88°·24	89°·21
July	74°·31	76°·87	80°·78	82°·71	83°·48	81°·61
August	74°·53	78°·20	81°·30	83°·04	84°·03	82°·40
September	75°·09	78°·03	81°·32	82°·39	82°·89	84°·02
October	76°·14	77°·02	80°·16	79°·21	77°·55	83°·17
November	76°·39	77°·64	76°·75	71°·73	67°·96	73°·04
December	76°·57	74°·59	71°·03	66°·14	62°·17	72°·36
1883.						
January	75°·85	73°·46	67°·64	62°·27	57°·98	64°·90
February	75°·02	70°·26	65°·10	60°·70	56°·43	65°·75
March	74°·23	69°·43	66°·45	64°·83	65°·87	75°·89
April	73°·89	70°·94	71°·00	74°·13	79°·53	86°·55
May	73°·97	73°·09	76°·72	81°·37	86°·51	90°·34
June	73°·96	76°·17	79°·29	83°·44	87°·04	90°·89
July	74°·32	76°·82	80°·70	83°·00	84°·55	83°·54
August	74°·90	78°·20	81°·42	83°·43	84°·89	83°·85
September	75°·66	78°·97	81°·12	81°·74	82°·19	82°·86
October	76°·16	78°·93	79°·50	78°·23	76°·70	82°·08
November	76°·28	76°·03	74°·20	69°·78	65°·61	70°·95
December	76°·12	73°·59	68°·71	62°·50	57°·43	66°·12

Actinometry.—Sergeant Rowland, R.E., who was sent out towards the end of last year, landed in India on 1st November, but owing to the impracticability of proceeding at that season to Leh—for the passes were closed,—he was directed by Mr. Blanford to employ himself at the survey office, Dehra-Dún, in acquiring a familiarity by actual observations with actinometers in reducing the results, and in the taking and reducing of complete meteorological

observations. In January, Mr. H. G. Shaw was appointed as his assistant; and both these observers have been thoroughly instructed in the points named, as well as in the taking and reducing of observations for time with a sextant. In fact, nothing that might either directly or indirectly help them in their actinometric work at Leh has been left unshewn, and they started from Dehra on the 3rd October. It may be necessary to add that their lengthened delay in these parts was occasioned mostly by the lateness of arrival of the Leh instruments which, further, needed comparison with our standards before removal to Leh. The time thus apparently lost to actinometer work has been amply improved by the extended instruction given to the two observers. Among other instruments, they have been provided with a horizontal sun-dial, constructed at Roorkee for Leh, from data supplied by this office. They have also been supplied with forms specially devised and printed for the recording, calculating, and abstracting of their results; and full and detailed instructions, illustrated with diagrams, have been handed to them.

Major Trotter's actinometric observations (1873) have been reduced. Also, at Mussooree and Dehra, two observers were employed on 55 days in taking as many sets of actinometric observations, and one observer was similarly employed on 16 days: further, in order to ascertain factors for the conversion of results by the Leh instruments into terms of the standard actinometer, two men were employed in taking 79 sets of observations,—each set occupying on an average nearly a quarter of an hour.

The index errors of eight thermometers were determined, and three thermometers at high temperatures, artificially maintained, were compared with our standards, for the hospital of the 2nd Goorkhas.

Explorations.—The Explorer A— K—, who after an absence of over four years returned to India last November, has had his latitude and boiling-point observations translated and reduced—the former furnishing the values of latitude for 22 stations, and the latter the height of nearly 70 stations. In a number of instances there being *several* determinations for the same station, the total number of observed latitudes actually computed is 171, and of heights is 225. The explorer's instruments were previously tested and their errors deduced.

The orthography of proper names occurring in his route has been examined and finally settled for adoption in the letter-press as well as a map of his work. His diary has been translated into English. It is hoped that his map may be published in time for the present administration report.

TYPOGRAPHIC BRANCH.

The usual table shewing the work annually performed by this branch during the past five years is given below, the unit (a page of foolscap) being the same throughout:—

	1878-79.	1879-80.	1880-81.	1881-82.	1882-83.
Pages composed	1,844	1,421	1,363	1,283	1,381
„ printed	590,043	494,136	480,672	471,616	475,586

An analysis of the pages composed furnishes the following:—

		Pages.
For Professional Volume VII } North-East Quadrilateral	... ...	15
„ „ „ VIII }	... ...	141
„ „ „ IX (Longitude Operations) ...	... ...	279
„ „ „ Southern Trigon	... ...	165
	Total ...	600
For Synoptical Volume XIV	... ...	13
„ „ „ XV	... ...	14
„ „ „ XVI	... ...	18
„ „ „ XVII	... ...	20
„ „ „ XVIII	... ...	16
„ „ „ XIX	... ...	15
„ „ „ XX	... ...	11
„ „ „ of North Afghanistan Triangulation ...	... ...	85
„ Routes in Western Himalaya and Kashmir, &c. ...	... ...	44
„ Spirit-leveled heights, sections I and II, Southern India	... ...	48
„ Forest Department	... ...	103
„ Charts, orders, memoranda forms, &c.	... ...	394
	Total ...	781

PHOTO-ZINCOGRAPHIC BRANCH.

THE following are the particulars of the work executed by the Photo-zincographic Branch during the year :—

Maps.

SUBJECT.	When published.	Number of parts.	Number of sheets printed.
Prints of maps published in former years	.....	54	2,737
Astor and Gilgit with surrounding country	October 1882	1	211
Index to the Nepal boundary survey	,, ,,	1	105
Map of the routes followed by explorers in Nepal, by Captain Harman	November ,,	1	622
Cutch survey, sheet No. 20	,, ,,	1	132
Index to the Guzerat survey	,, ,,	1	660
Ditto Cutch survey	,, ,,	1	656
Sketch map illustrating the explorations of M—S—in and around Badakshan, 1878-81	,, ,,	1	604
Kumaun and Garhwál Forest map, sheet No. LVI *(for Forest Department)* ...	December ,,	1	121
Ditto ditto ,, No. LVII ...	,, ,,	1	65
Ditto ditto ,, No. LVIII ...	,, ,,	1	66
Cutch survey, sheet No. 19	,, ,,	1	130
Turkistan map ,, No. 1, 6th edition	,, ,,	1	640
Ditto ,, No. 2 ,, ...	,, ,,	1	846
Ditto ,, No. 3 ,, ...	,, ,,	1	719
Ditto ,, No. 4 ,, ...	,, ,,	1	651
Landour cemetery plan	January 1883	1	43
Rainfall and forest trees in India *(for Forest Department)* ...	February ,,	1	396
Cutch survey, sheet No. 21	March ,,	1	132
Index to the Turkistan map	,, ,,	1	800
Jaunsár Báwar	April ,,	1	135
Guzerat survey, sheet No. 49, section 7 *(Dáng Forest)* ...	,, ,,	1	91
Ditto ditto ,, 15 *(ditto)* ...	,, ,,	1	85
Ditto, sheet No. 17, section 2	,, ,,	1	83
Ditto, ,, No. 76	June ,,	1	487
Disputed boundary map for the Malwa Survey Party ...	,, ,,	1	18
Parts of Arabia and Persia, No. 1	July ,,	1	229
Ditto ditto, No. 2	,, ,,	1	209
Sketch map of Shirani country	,, ,,	1	128
Afghanistan, edition 1883	,, ,,	2	282
Kumaun and Garhwál Forest map, sheet No. XLV *(for the Forest Department)* ...	September ,,	1	76
Ditto ditto, ,, No. LXV *(ditto)* ...	,, ,,	1	80
Ditto ditto, ,, No. LXVI *(ditto)* ...	,, ,,	1	19
Reconnaissance in S. W. Baluchistan for the Q. M. G.'s Department	,, ,,	1	214
Hakim's Explorations in Afghanistan	,, ,,	1	110
Guzerat survey, sheet No. 33, section 2	,, ,,	1	4
Ditto, ,, No. 49, ,, 2 *(Dang Forest)* ...	,, ,,	1	20
Total ...	.....	91	12,300

In addition to the foregoing, 278 blue prints and 105 silver prints (11 subjects) were prepared for the executive officers :—

Charts.

SUBJECT.	When published.	Number of parts.	Number of sheets printed.
Index chart to the Burma triangulation	October 1882	1	35
Assam Valley, season 1876-78, preliminary	November ,,	2	136
Great Indus Series, portions of final charts Nos. 1 and 2 (for use of district officers)	,, ,,	1	25
Eastern Frontier Series, skeleton, illustrating the operations of 1881-82 (16 miles=1 inch)	January 1883	1	430
Ditto ditto (30 miles =1 inch) ...	,, ,,	1	480
East Calcutta Longitudinal Series, final	February ,,	1	392
Gurwáni Meridional Series, final	March ,,	1	382
Triangulation in Independent Sikkim and portions of Nepal and Bhutan	June ,,	1	85
Brahmaputra Meridional Series, final	August ,,	1	377
Bhopal and Malwa chart *(for the Malwa Survey Party)* ...	September ,,	1	19
Assam Longitudinal Series, 1852-78, preliminary	,, ,,	1	66
Kohát Chart, 1880-83 *(for the Kohát Survey Party)*	August ,,	1	15
Total ...	.....	13	2,441

Diagrams.

Subject.	When published.	Number of copies printed.
Polygons and other figures to illustrate figural reductions for volumes of the Great Trigonometrical Survey bench marks, &c.	October 1882	711
	November ,,	2,083
	December ,,	986
	January 1883	1,884
	February ,,	896
	March ,,	12
	April ,,	333
	May ,,	668
	June ,,	128
	August ,,	1,284
	September ,,	1,510
Total ...	.....	10,495
Professional and office forms	.....	30,195

The total number of negatives taken is 648, the number of chromo-carbon prints 1,143 and the number of transfers to zinc 250.

Contrasting the work performed since 1878-79, we have:—

Year.	Maps.	Blue prints.	Silver prints.	Charts.	Diagrams.	Forms, &c.
1878-79	20,229	1,394	353	2,642	2,603	20,070
1879-80	15,100	588	1,021	3,821	2,271	17,909
1880-81	15,659	414	52	1,886	3,367	19,508
1881-82	13,471	460	726	3,486	4,789	24,987
1882-83	12,300	278	105	2,441	10,495	30,195

An abstract of the work executed during the past five years stands thus—

Subject.	Number of Prints.				
	1878-79.	1879-80.	1880-81.	1881-82.	1882-83.
Maps, charts, diagrams	25,474	21,192	20,912	21,746	25,236
Blue prints	1,394	588	414	460	278
Silver prints	353	1,021	52	726	105
Forms, &c.	20,070	17,909	19,508	24,987	30,195

The money actually realized and credited to Government from sales of maps, &c., during the year, is Rs. 705-13-3.

DRAWING BRANCH.

The following tables exhibit the work performed in this branch:—

Description of Work.	Number of sheets or diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Final Charts.				
Brahmaputra Series	1	.....	4	For reduction by photo-zinco-graphy.
Eastern Frontier Series	1	.....	4	
Assam Longitudinal Series	.....	1	4	
Preliminary Numerical Charts.				
Burma Party, seasons 1875 to 1880	.....	2	4	For photo-zinco-graphy.
Eastern Frontier Series, seasons 1879 to 1882 ...	1	.....	4	
Assam Longitudinal Series, seasons 1862 to 1860, 1868-69, and 1877-78	1	.....	8	
Compilation.				
Spirit-leveled height charts, sheets Nos. 67, 81, 83, 88, 6 (2nd edition), and 12 (3rd edition)	1	5	2	For photo-zinco-graphy.
Atlas reduction of sheet No. 3, Dehra Dún and Sowalik Survey...	1	.....	Atlas scale	For incorporation in atlas sheet No. 48.

Description of Work.	Number of sheets or diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Compilation—concluded.				
Trans-frontier map No. 9 (3rd edition)	.....	1	8	For reduction by photo-zincography.
Sketch map illustrating the explorations of M—S in and around Badakshan, 1878-81	1	.....	8	For reduction by photo-zincography.
Map of parts of Arabia and Persia for the Resident in the Persian Gulf	2	.....	32	For photo-zincography.
Skeleton chart of Eastern Frontier Series illustrating the operations of 1881-82	1	.....	16	For reduction by photo-zincography.
Map of Astor and Gilghit with surrounding country (with additions to 1882)	1	.....	4	For photo-zincography.
Map of rainfall and forest trees in India (for Forest Department)	1	.....	128	For reduction by photo-zincography.
Maps to illustrate explorer A— K—'s route survey in Tibet and Mongolia	3	.....	8	For reduction by photo-zincography.
Map of Afghanistan from Turkestan, 6th edition ...	1	.....	32	For enlargement by photo-zincography.
Sketch map of routes traversed by European and Native explorers beyond the British Frontier from 1865 to 1883	1	.....	64	For photo-zincography.
General index to the sheets of the several surveys in the Bombay Presidency	1	.....	32	
Chart showing points from the North-West Himalaya degree sheets for Executive Engineer, Lahore Division	1	.....	1	
Chart showing points within a radius of 10 miles round Mecan Meer for Executive Engineer, Lahore Division	1	.....	½	
Chart of part of Gilghit triangulation	1	.....	8	
Final additions for 6th edition of Turkestan sheets Nos. 1, 2, 3, and 4	4	.....	32	For photo-zincography.
Miscellaneous.				
Corrected Káthiáwár Survey sheets for 2nd edition, Nos. 5, 8, 10, 11, 20, 14, 21, 22, 23, 24, 33, 35, 43, and 45	.....	.....	.....	For reduction by photo-zincography.
Plotted explorer A— K—'s route survey from Lhása to Saitu and thence to Dárchendo, Báthang, Sáma, and on to Chetáng near Lhása	.....	.....	.....	
Examined 173 proofs of maps and charts	.....	.....	.....	
Examined and corrected the following:—Atlas reductions, Guzerat Survey, sheets Nos. 33, 34, and 77; Cutch Survey, sheets Nos. 17, 19, 20, and 21 ...	.....	.....	.....	
Examined and reported on, corrected and passed for the press, the following maps:—Guzerat Survey, sheets Nos. 17 and 17, section 1; sheet 34, sections 2, 3, and 4; sheet 33, sections 2 and 4; sheet 35; sheet 49, sections 2, 7, 15, and 16; and sheet 76; Cutch Survey, sheets 1, 2, 6, 17, 18, 19, 20, and 21 ...	.....	.....	.....	For photo-zincography.
Corrected for the press for reprints, sheets Nos. 3 and 4, Jaunsár Báwar (original maps)	.....	.....	.....	
Calculated the area of the North-West Provinces and Oudh for Mr. Fisher's Gazetteer of the North-West Provinces and Oudh	.....	.....	.....	
Prepared overlaps of chart of Northern Triangulation of Afghanistan for the press	.....	.....	.....	For reduction by photo-zincography.
Extracted and tabulated latitudes and longitudes of numerous places in the districts of Azamgarh, Muttra, and Allahabad, for Mr. Fisher's Gazetteer of the North-West Provinces	.....	.....	.....	
Colored 9,382 maps	.....	.....	.....	
Prepared a tracing of Revenue Survey Triangulation Chart of Hazara	.....	.....	.....	
Drew diagram of scale for measurement of sun-spots ...	.....	.....	.....	For photography.
Drew and printed orthographical projection of zenith circles for Leh	.....	.....	.....	
Drew 28 different forms, professional and others ...	.....	.....	.....	For photo-zincography.
Prepared tracings of a portion of district Simla for Commissioner of Umballa	.....	.....	.....	
Copied plan of dome for new photo-heliograph observatory	.....	.....	.....	
Copied ground plan of new photo-heliograph observatory	.....	.....	.....	

Description of Work.	Number of sheets or diagrams.		Scale, one inch = miles.	Remarks.
	Finished.	In hand.		
Miscellaneous—concluded.				
Prepared a diagram of Captain George's barometer ...	.....	.....	.....	For photo-zincography.
Prepared copies of 3 Tibetan pictures	.....	.....	.....	
Marked boundaries of districts and tribes on Assam Valley Charts	.....	.....	.....	
Copied margins of certain sheets of the Guzerat Survey for the Executive Officer	.....	.....	.....	
Plotted a portion of Government Telegraph line of levels near Ghazipur for Executive Engineer	.....	.....	.....	
Prepared traces of sketch map of country between Nepal and Bengal...	.....	.....	.....	
Prepared a diagram of sundial for Leh ...	.....	.....	.....	
Drew diagrams of section of road for Forest Department	.....	.....	.....	For reduction by photo-zincography.
Plotted Sub-Surveyor Ahmad Ali's points north of Hazara	.....	.....	.....	
Prepared Index Chart to Burma Triangulation ...	.....	.....	.....	For photo-zincography.
Tabulated a large number of heights in Kashmir, Ladak, &c., for Colonel Godwin-Austen	.....	.....	.....	
Prepared trace of part of Bashahr for Major Bailey ...	.....	.....	.....	
Prepared 6 traces of boundary between Nepal and Bengal...	.....	.....	.....	
Prepared extract from Chart of the North-East Longitudinal Series for Colonel Tanner	.....	.....	.....	
Miscellaneous current duties, including preparing for the press, several maps of the Topographical Surveys and of the Forest Survey, transliterating Russian names, reducing maps by pantagraph, and affording assistance to officers and to the Photo-zincographic Office, &c., &c.	.....	.....	.....	

CORRESPONDENCE AND STORES.

The year's correspondence is represented by over 2,700 letters, and memoranda (inclusive of those already mentioned in connection with the protection of stations). Of these, some 700 are specially debitable to the office of the Officiating Deputy Surveyor-General from 12th February to 30th September 1883.

Of instruments, &c., received and despatched, there were—

Instruments despatched	221
Ditto received	125
Stores, articles despatched	177
Ditto received	82
Presenting a total of packages and parcels received	280
Ditto ditto ditto despatched	129

SOLAR PHOTOGRAPHY.

Mr. L. H. Clarke, Surveyor, 2nd grade, has continued to work as Solar Photographer, assisted by Mr. C. F. Guthrie. The working facts for the year are given in the subjoined table:—

1882-83.	Number of Days.			Number of Negatives.					Number of working days when solar phenomena were—	
	When negatives were taken.	Failures. From bad weather.	Failures. From various causes.	Failures. Total.	Solar phenomena. Spots and facules.	Spots only.	Facules only.	None.	Runs.	Total.	Visible.	Absent.
October	31	.....	.....	.....	88	.....	... ..	.....	26	114	31	.....
November	30	.....	.....	.....	85	.....	.....	.....	9	94	30	.....
December	29	3	.....	.....	79	.....	.....	.....	7	86	23	.....
January	26	5	.....	.....	72	.....	.....	.....	19	91	26	.....
February	27	1	.....	.....	74	.....	.....	.....	21	95	27	.....
March	29	2	.....	.....	81	.....	.....	.....	22	103	29	.....
April	29	1	.....	.....	82	.....	.....	.....	21	103	29	.....
May	29	1	.....	.....	81	.....	2	.....	26	109	29	.....
June	28	...	.....	.....	78	.....	.....	.....	10	88	28	.....
July	15	16	.....	.....	43	.....	.....	.....	.....	43	15	.....
August	21	10	.....	.....	58	.....	.....	.....	.....	58	21	.....
September	24	6	.....	.....	62	.....	.....	.....	.....	62	24	.....
Total ...	318	47	.....	.....	882	.....	2	.....	161	1,043	318	.....

This table shows that during the year photographs of the sun were obtained on 318 days, and that of the 884 negatives taken, all of which exhibit solar phenomena, but 2 show faculæ only. From these negatives 720 silver prints were taken.

In addition to the negatives mentioned, 161 were taken for runs. These, however, were finally discontinued on 14th June 1883, as it was found that the necessary resetting (for 8-inch sun negatives) of the exposure slit between the two images, tilts the teleseope in declination, whereby the run is made to exhibit a want of adjustment in the instrument although the instrument is in perfect adjustment. The usual examination of the instrument for adjustment is always regularly made.

The usual 4-inch negatives gave place for a time to the 8-inch ones on 14th November 1882; they were, however, resumed on 19th December 1882 at the request of the Astronomer Royal, and were subsequently finally given up in favour of the 8-inch negatives on 30th May 1883. These latter have elicited very favourable notice from both General Strachey and Mr. Christie, the Astronomer Royal for Greenwich.

The usual table of percentages regarding the daily visibility of the sun and the presence of features (*i.e.*, spots and faculæ) is subjoined:—

Year.	In 100 days the sun was invisible on—	In 100 working days features were present on—
1877-78	9 days (obtained from 273 days) ...	30 days (obtained from 248 working days).
1878-79	11 „ 89 „ ...	28 „ 79 „
1879-80	14 „ 289 „ ...	82 „ 232 „
1880-81	15 „ 365 „ ...	96 „ 307 „
1881-82	10 „ 365 „ ...	100 „ 328 „
1882-83	13 „ 365 „ ...	100 „ 318 „

Contrasting the percentages of days of invisibility above given with those for Greenwich, as furnished by the Astronomer Royal's reports, we have—

Year.	At Dehra, year ending 30th September.	At Greenwhich, year ending 20th May.
1880-81	15	60
1881-82	10	45
1882-83	13	45

As mentioned in the reports of former years, the photographs at Dehra are take on every day of the year (including Sundays) that the sun is visible.

The despatch to England of the negatives and of the silver prints has been continued weekly with unfailing regularity.

The New Photo-heliograph.

As noticed in last year's report, the new photo-heliograph, giving 12-inch negatives, arrived during July 1882. It was first set up in a large room in order that the necessary particulars for an observatory might be obtained; after this had been done, a considerable time was occupied in getting plans and estimates for the dome drawn out at the Canal Foundry workshops at Roorkee, the most accessible iron foundry to Dehra. It was not considered advisable to lay the foundations of the observatory until these plans were complete, lest any alterations should become necessary and subsequent difficulties should arise in adapting the dome to the walls. In the meantime the pillar for the instrument was built to about a height of nine feet so that the masonry might have time to settle together and dry thoroughly before the instrument was placed on it.

It was not until December that the plan of the dome was received, and then the foundations of the observatory were at once laid and the building pushed on as fast as practicable; and by the 7th March the walls were ready for the dome. But the first instalment of portions of the dome did not arrive till the 4th April. Other portions came by degrees. By the 9th May the skeleton of the dome had been mounted, and then it was unfortunately discovered that the base of the dome was too weak for the superstructure, and that instead of the base remaining circular it took the form of an ellipse.

A great deal of time was now occupied in restoring the circularity of the rail on which the dome runs—this having been forced out of shape, and in strengthening the base of the dome by the addition of an extra sole-plate of wider dimension than the first.

By the 1st August this had been done, and the dome had been nearly covered in with steel sheeting, but the lining of the dome with wood remained.

When the dome was nearly finished, it was found that the contrivance for revolving it, as well as that for opening and closing the shutter, were unworkable, and alterations had to be made; scientific methods giving place to very primitive ones. These necessary alterations were effected and the instrument thereafter placed in position.

Monthly Meteorological Results taken from the Register kept at the Head-quarters Office, Trigonometrical Branch, Survey of India, Dehra-Dún.

YEAR AND MONTH.	BAROMETER REDUCED TO 32° FAH.						HYGROMETER.				THERMOMETER.								RAIN.		WIND.	CLOUD.	
	AT 9-30 A.M.			AT 3-30 P.M.			AT 9-30 A.M.		AT 3-30 P.M.		DRY BULB.					WET BULB.							
	Highest.	Lowest.	Monthly mean.	Highest.	Lowest.	Monthly mean.	Monthly mean temperature of dew-point.	Monthly mean humidity.	Monthly mean temperature of dew-point.	Monthly mean humidity.	Maximum in sun's rays.	Minimum on grass.	Maximum in air.	Minimum in air.	Monthly mean in air.	Maximum in wet.	Minimum in wet.	Monthly mean wet.	Number of days it fell.	Fall in inches.	Most frequent direction.	At 9-30 a.m.	At 3-30 p.m.
1882.																							
October	27·770	27·473	27·654	27·677	27·358	27·567	57·6	·561	55·3	·458	105·1	45·5	87·2	56·1	72·6	74·6	49·7	62·7	1	·39	N.	.....	1
November	·859	·663	·797	·819	·602	·705	47·0	·549	45·7	·383	90·6	36·8	80·0	46·6	63·1	65·3	41·8	53·7	1	·12	,,	.....	1
December	·900	·652	·794	·813	·585	·713	43·0	·561	41·6	·402	88·0	34·1	75·6	43·0	58·9	67·3	39·1	50·6	.....	.....	,,	2	3
1883.																							
January	·910	·539	·793	·555	·481	·721	41·6	·658	41·2	·451	83·2	28·7	71·3	35·4	54·2	56·3	33·7	47·0	4	5·29	W.	5	5
February	·826	·620	·739	·768	·552	·659	41·0	·606	40·3	·367	91·2	22·8	76·7	34·7	56·0	64·6	33·4	47·9	.....	.....	,,	3	3
March	·779	·550	·671	·763	·450	·597	48·9	·563	46·4	·392	101·8	33·8	86·0	45·5	64·2	64·3	40·2	54·0	6	1·65	N.	4	5
April	·667	·453	·584	·596	·365	·488	52·4	·374	49·8	·255	114·2	43·3	97·8	52·3	77·9	74·0	46·3	61·5	1	·31	,,	2	3
May	·637	·331	·461	·545	·261	·380	53·8	·341	52·3	·280	119·8	55·5	104·0	61·5	83·9	75·9	55·8	64·7	5	1·25	N.W.	1	
June	·568	·312	·401	·477	·219	·315	69·8	·628	70·0	·545	116·4	60·6	100·4	66·1	83·8	80·3	62·9	72·6	14	13·23	Calm.	4	4
July	·558	·262	·392	·431	·219	·324	74·9	·827	76·6	·783	114·8	65·9	89·3	76·1	80·3	81·5	60·8	74·7	20	17·20	,,	8	8
August	·526	·324	·442	·482	·283	·370	73·8	·805	74·8	·743	111·7	64·8	90·0	69·9	79·6	86·0	65·9	74·0	21	14·25	N.	6	6
September	·658	·391	·534	·588	·317	·455	71·4	·801	73·0	·749	107·0	58·7	87·9	66·0	77·7	83·5	60·5	71·8	12	5·58	Calm.	5	6

NOTE.—The height of the barometer cistern above mean sea-level at Kurrachee is 2,232·42 feet.

Mean velocity in miles of the winds which blew at Dehra-Dún during the twelve months of 1882-83, *for each hour of the day.*

Civil Hours.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.
0 to 1	2·68	3·17	2·83	2·41	2·32	2·63	3·09	3·03	1·83	1·19	1·38	1·09
1 „ 2	2·42	2·67	2·69	2·07	2·11	2·39	2·97	2·29	1·02	0·74	1·26	0·91
2 „ 3	2·28	2·00	2·40	2·00	2·14	2·23	2·85	2·00	2·40	0·97	1·41	0·87
3 „ 4	2·19	2·30	2·23	1·59	1·75	2·00	2·10	1·81	1·70	1·16	1·02	1·00
4 „ 5	1·94	1·83	1·90	1·64	1·66	2·10	2·28	1·45	1·33	1·19	1·24	0·83
5 „ 6	1·61	1·77	1·60	1·93	1·57	1·38	0·83	1·45	1·77	1·26	1·28	0·52
6 „ 7	1·61	1·70	1·40	1·82	1·61	1·30	1·03	1·61	1·13	1·13	0·90	0·35
7 „ 8	1·06	1·43	1·57	1·75	1·07	1·37	1·43	1·39	1·37	1·48	1·03	0·26
8 „ 9	1·36	1·33	1·13	1·06	1·64	1·35	1·46	1·68	2·27	1·39	1·31	0·22
9 „ 10	1·58	1·63	1·23	2·11	2·39	2·00	1·93	2·84	2·73	2·23	2·07	0·65
10 „ 11	2·00	2·27	1·77	2·94	2·71	2·61	2·71	4·32	2·67	2·45	2·36	0·96
11 „ 12	2·58	2·63	2·57	3·17	3·25	3·19	3·43	5·06	2·97	2·57	2·12	1·22
12 „ 13	2·97	2·60	2·90	3·32	3·21	3·52	4·35	4·90	2·93	2·45	2·75	1·58
13 „ 14	3·65	2·90	2·86	3·16	3·96	3·87	5·47	4·77	3·03	2·33	2·75	1·96
14 „ 15	3·39	2·97	2·55	3·29	4·29	4·09	4·86	5·68	3·13	3·03	2·61	2·13
15 „ 16	2·68	2·90	2·37	2·61	3·89	3·74	5·02	5·61	3·20	2·71	1·96	1·54
16 „ 17	1·32	1·40	1·20	2·42	2·57	3·48	5·76	6·00	2·80	2·45	1·86	1·17
17 „ 18	0·84	0·70	0·53	1·58	1·79	1·65	5·34	5·39	2·37	1·81	0·96	0·25
18 „ 19	2·65	1·83	1·13	1·72	0·57	8·00	2·45	3·03	1·77	1·10	0·71	0·29
19 „ 20	3·16	3·70	2·40	2·21	1·18	2·19	2·10	2·13	1·09	0·96	0·39	0·72
20 „ 21	3·42	3·50	2·87	2·97	1·39	2·87	2·31	2·61	1·37	0·81	1·86	1·04
21 „ 22	3·81	3·07	2·87	2·86	2·18	2·94	3·28	2·55	2·13	1·00	1·71	0·83
22 „ 23	3·55	3·33	2·90	2·62	2·57	3·19	3·07	2·53	1·90	1·10	1·61	1·33
23 „ 24	3·45	3·30	2·70	2·56	2·18	3·16	3·69	2·35	1·97	1·48	1·61	1·21
Sums ...	58·43	57·33	51·11	57·01	55·52	61·48	75·39	76·73	54·54	39·15	40·38	22·92
Average ...	2·43	2·39	2·13	2·38	2·31	2·57	3·14	3·20	2·26	1·63	1·70	0·96

Memorandum regarding system proposed and instructions issued for preparation of Record-of-Rights in Benares.

The Settlement *munsarims* to take the field with the Survey inspector and his *amins*. One inspector having under him 8 or 9 *amins*, it will under ordinary circumstances be advisable to have two *munsarims* per inspector's circle. The *amin's* first duty is to take up the boundaries and divide the village off into squares.

While the *amin* is thus employed, the inspector and *munsarim* are directed to prepare the *hissa-kushi* or *fard-noiyat* (share list) of the village, which document forms the basis of the *khewat* (statement of proprietary rights). They also collect the *zemindars* and tenants, and with the aid of the *putwari* prepare the *jamabandi* (rent-roll) slips for each tenant, &c., by entering the headings of cultivator's name, &c., thereon. By the time this has been done the *amin* is ready to commence his field measurements.

The Survey inspector and *munsarims* are instructed to see the *amin* and *putwari* well forward in the work of field survey before they leave the spot. They will see the entries of on an average about 50 fields (the exact number depends on the size of the village) made, and be certain that the *putwari* and *amin* thoroughly understand the system and instructions issued before they pass on to the next village. These instructions are as follows:—

As each field is measured the *putwari* has to make the necessary entries regarding that field in the form of a Nagri *khasra*, and also to enter the field in the *jamabandi* slip of the tenant to which it belongs. The Survey *amin* at the same time has to make the same entries in the form of an Urdu *khasra*. As each succeeding field is measured and numbered the same procedure regarding it has to be gone through and the entries written up in the presence of the *zemindar* or his authorized agent, and the cultivator.

In cases of dispute, the disputed entry will be left blank and the disputed number jotted down on a separate slip by both Survey *amin* and *putwari*. While this is going on, the Settlement *munsarim* and Survey inspector have orders each in turn, to visit every working party, attest the entries already made, see that the Survey *amins* and *putwaris* understand

their instructions, and are working up to them, and in fact to exercise the strictest supervision in every way.

Following this plan, we have, by the time the measurement of the village is completed, the following papers :—

1. The original field map.
2. The rough Urdu *khasra* written by the Survey *amin*.
3. The rough Nagri *khasra* written by the *putwari*.
4. The *jamabandi* slips.
5. The list of disputes.
6. The *hissa-kushi* or *fard-noiyat* as prepared in rough by the Settlement *munsarim*.

Up to this point the areas are wanting in all these papers.

These papers are then handed over to the Survey inspector and *munsarims*, who conjointly and each in his separate department, thoroughly test the papers. The undisputed *jamabandi* slips are attested and signed in the presence of the *munsarim* by *zemindar*, tenant, and *putwari*. In each case of dispute the *munsarim* has to make a short abstract of the facts of the case as stated by the parties. This abstract is in the form of a *jamabandi* slip, and the disputed and undisputed slips are kept separate and distinct. This done and the papers passed as correct (barring disputes which have to be legally dealt with), the original field map and Urdu *khasra* are handed over to the Survey Department while the Hindi *khasra, jamabandi* slips, and rough *khewat* are kept in the Settlement Department.

On receipt of the original field map and Urdu *khasra*, the Survey Department at once furnish the Settlement with a preliminary trace of the map, retaining the original field map and Urdu *khasra* in their own hands.

Up to this point the Settlement Department have the following :—

1. Preliminary trace of map.
2. Rough Nagri *khasra*.
3. Rough *jamabandi* with disputes undecided.
4. Rough *khewat*.

Still with no areas.

The preliminary trace received, these papers go direct to the Settlement Deputy Collector, who, as soon as he can, has to visit the village, attest the *khewat* and *jamabandi* slips, and settle the disputes. Duplicates will then be made of all the *jamabandi* slips for issue to the tenants.

While the Deputy Collector is doing all this, the Survey Department are employed in inking up their maps and working out their field areas. This completed, the Survey Department furnish the Settlement with a field register and also a complete Urdu *khasra* with the areas of each field entered in acres and *bighas*. Here the work of the Survey Department practically closes.

The next step is to enter the areas in the *jamabandi* slips which are then completed. The *jamabandi* will then be notified, and an attested copy of each slip given to the tenant affected. On distribution of these slips, notice will be given that a further period of fifteen days will be allowed for objections.

Note.—Both *zemindar* and tenant have had ample time to raise any objections before this stage.
(I would propose, therefore, not to give more than 15 days after distribution of slips.)

This period elapsed without objections having been filed, the *zemindar* and tenants will be held to have acquiesced to the *jamabandi*, which with the *khasra* and *khewat* will then be arranged and filed in the usual manner.

One other point may be noted, and that is that instructions have been issued to all Settlement *munsarims* to keep a record, in a narrative form, of all points in the constitution of any village they have to deal with, which are in any way worthy of note.

This will be scrutinized by the Settlement Deputy Collector, who will also make enquiries and add his remarks. This paper will form the basis of the memorandum which is recommended by the Committee to take the place of the *wajibularz*.

The objects which we have tried to keep in view in making these arrangements are :—

1. To do the work as rapidly and cheaply as possible, consistently with accuracy.
2. To strengthen the hands of both the Survey and Settlement Departments by a system of mutual help and assistance.
3. To, as far as possible, avoid the work of one department being retarded by the operations of the other.
4. To minimise the worries and harassings of the *zemindar* and tenant which are to some extent inevitable in all Settlement work.

As far as we have gone as yet, we have met with no insuperable difficulties in carrying out this system, and we see no course better adapted to attain the objects we have had in view.

13-1-83.

F. W. Porter.

W. Barron.

m

No. 961, dated Camp Lucknow, the 17th April 1883.

From—J. R. REID, Esq., Offg. Secretary to the Government of the North-Western Provinces and Oudh,

To—The Secretary to the Govt. of India. Revenue and Agricultural Department.

WITH reference to your office No. 128, dated 21st March 1883, I am directed to submit, for the information of His Excellency the Governor-General in Council, copies of notes showing (1) the points brought up for discussion; (2) the conclusions arrived at at a meeting of Revenue and Survey Officers held at Benares in January last.

Note showing the points brought up for discussion at the meeting held at Benares on 11th January 1883.

The Lieutenant-Governor has decided that—

(1) Settlement operations should be commenced in Gorakhpur and Basti as soon as Cadastral parties are available, that is, next year, 1883-84.

(2) The Survey should be carried out by means of *amins*, not by *putwaris* acting as surveyors.

(3) The revised assessment of the land revenue should be prepared at the same time as the Survey and the preparation of the Record-of-Rights.

(4) Settlement Officers should be put in charge of the work from the commencement of the survey operations.

The points to be discussed now, are :—

I.—How are the surveying and record-preparing establishments to work :—

either

(i) as hitherto, the former preparing maps and field books in one year, and the record establishment following with the preparation of the *khasra* and *jamabandi* in the next; or

(ii) as now in the up-lands of Mirzapur, the surveyors preparing a *khasra* along with the map, which *khasra*, after the preparation of *jamabandi* slips, is made over for attestation and completion to the Settlement Officer; or

(iii) as now in Benares, the Settlement Officer's establishment working along with the surveyors and preparing their own copy of the *khasra* and the *jamabandi*.

II.—How are settlement operations to be condensed and contracted, so as to reduce the cost and harassment to the people and Government :—

(i) in regard to the preparation of the *khewat*;

(ii) in regard to the preparation of the *wajibularzi*—(is this document necessary?);

(iii) in regard to the adjudication of disputes as to rights arising from the preparation of the Record-of-Rights (should the powers of Civil Courts be conferred upon Settlement Officers?);

(iv) in regard to the preparation of the revised assessments—

(*a*) by assessing as much as possible on actuals;

(*b*) by adopting a simple system of classifying and valuing soils and crops;

(v) in regard to the adjustment of rents in cases in which they may be unduly low (or high?) as compared with prevailing rents.

Note of conclusions arrived at on the foregoing points.

PRESENT:

The Lieutenant-Governor and Chief Commissioner.
C. P. Carmichael, Esq., C.S.I., Senior Member, Board of Revenue.
C. A. Daniell, Esq., Commissioner of Benares.
A. Cadell, Esq., Collector of Mirzapur.
W. Irvine, Esq., Collector of Ghazipur.
F. W. Porter, Esq., Joint-Magistrate, Benares.
Colonel Anderson, Deputy Superintendent of Survey.
Major Barron, Deputy Superintendent of Survey.
J. R. Reid, Esq., Officiating Secretary to Government.

1.—(iii) The method now followed in Benares is considered the best for the purpose of ensuring accurate and expeditious work. The defect in it is that, at the final attestation of the *jamabandi* slips, the areas of the fields will not have been filled in, and that these must be filled in subsequently in copies of the slips which will be subsequently distributed to the

occupiers, and to the entries in which time must be allowed to the occupiers for objections. A report to be made on the system at the end of six months. Mr. Porter to submit a copy of the instructions issued by him and the Deputy Superintendent of Survey for the guidance of their subordinates.

II.—(1) The *khewat* to be prepared and attested, as the "*fard hissa-kushi*" is now prepared, for each estate before the survey operations begin.

(2) The *wajibularz* to be given up; any necessary explanations that may be required regarding the constitution of the *mahal*, or other similar matters, to be entered in a note to the *khewat*.

(3) The Settlement Officer not to have Civil Court powers.

(4) Assessment to be as much as possible on actuals, that is (declared rental corrected for *sir* and rent-free and other similar land), the principle being that when the Settlement Officer departs from actuals as the basis of assessment, he must fully justify his action.

As simple a classification of soils to be adopted as possible, for purposes of valuation, as a standard by which to judge the actual (declared) assets. The classification to be made by the survey officials as survey proceeds, under instructions received from the Settlement Officer and Deputy Superintendent of Survey. The soils of culturable waste might be classified in the same way. The soils will also be coloured on the maps.

The prevailing rates for the different classes of soil to be ascertained, as at present, by comparison of existing rent-rolls and by personal enquiry. Settlement Officer on no account to "assume" rates for the purposes of assessment as has hitherto been done, such rates having sometimes been in excess of those *actually prevailing*.

(5) When assessment is made on the actuals, the Settlement Officer to have nothing to do with enhancement of rents. When the actuals have not been accepted as the basis of assessment on the ground that the rental is not trustworthy, or that it is, with reference to the rents prevailing elsewhere, on which rents the revenue of other estates has been fixed unduly low, the Settlement Officer may, on application from the landholder, fix rents according to the prevailing rates used or to be used in fixing the assessment. Rents unduly high not to be touched by the Settlement Officer.

Note in continuation of "Memorandum regarding system proposed and instructions issued for preparation of Record-of-rights in Benares, dated 13th January 1883, by Mr. F. W. Porter *and* Major W. Barron."

As far as the survey is concerned, the system laid down in the memorandum has been carried out, and I do not know that any modifications are required, as the arrangements seemed to answer.

As the work progressed, and both establishments got into the way of it, the out-turn of survey with *khasras* and *jamabandis* increased, and during the latter two months of the field season stood at 18 acres, including 22 fields, averaging ·83 of an acre per man per diem over all.

During season 1881-82, without *khasras* and *jamabandis*, the average out-turn was 21 acres, including 52 fields, averaging ·4 of an acre per man per diem over all.

Owing to the fact of the Survey preparing the *khasras* and *jamabandis*, which necessitated the presence of the *zemindars* and cultivators, the *amins* were able to obtain proper information regarding the fields, and therefore no *kiaris* were surveyed. The average size of the fields rose in consequence, and in the end nearly the same area was turned out per man daily with *khasras* as had formerly been without.

The advantages of having fewer fields extended to other parts of the survey work, and as there were fewer to ink up and calculate work which is done on contract, the savings on these heads made up for the extra cost of writing the *khasras* and *jamabandis*.

During the month of November 1882, before the *khasra* and *jamabandi* writing was begun, about 68,000 fields had been surveyed; but when the *khasras* of these were written up, over 26,000 of them were found to be *kiaris*, and were cut out of the maps, and that too in a part of the district (pargana Narwan) where there was very little rice cultivation. It will thus be seen what a great advantage it is for the surveyors to write up the *khasras* at the same time as they survey the fields.

During season 1881-82 the cost of the Field Survey (excluding Boundary Survey) in districts Ghazipur and Ballia was Rs. 112-15-1 per square mile, and this without *khasras* and *jamabandis*.

During this season, 1882-83, in Benares, judging from the actual expenditure of 9 months, and the probable for the next 3 months, the cost of the Field Survey (excluding Boundary Survey), including *khasras* and *jamabandis*, will be Rs. 112-12, so that the extra work has cost nothing.

In 1881-82 the cost of boundary and interior work was Rs. 151-8-1. This year, in Benares, the combined work with *khasras* and *jamabandis* will cost Rs. 140-4.

The total out-turn in Benares was 851 villages, 312,600 fields in 245,990 acres = 384·36 square miles. There have been made over to the Settlement Officer, Benares, 851 traces of villages, 851 Nagri *khasras* with *jamabandi* slips *without* areas, also Urdu *khasras with* areas, as follows :—

	Number of *khasras*.	Fields.	Acres.	Sq. miles.
Up to 12th July 1883	528	155,129	124,277·51	194·18
Now in transit	49	20,067	16,210·66	25·33
Total despatched ...	577	175,196	140,488·17	219·51
Remaining to despatch	274	137,404	105,501·83	164·85

The villages remaining are all drawn and calculated, but the areas cannot be closed till some boundary disputes and "*badars*" are settled. These are in hand, and it is expected that the rest of the records will soon be rendered.

From the above it will be seen that there is no need from a survey point of view, of expatiating on the advantages of the combined system. Surely the *khasras* and *jamabandis* as supplied by the survey have been of some value to the Settlement; and if so, then, since they cost the Survey nothing to prepare, the advantage is all clear gain. Besides this, the gain in even having the maps now showing *true fields* and corresponding with actual possession is worth a great deal, and saves in the records of the Settlement Department numberless useless entries which were necessitated by the Survey mapping *kiaris* when the two processes were not combined. The more I think of it, the more I regret the great waste of money and labour that there has been since the Cadastral Surveys were commenced, twelve years ago, and during the time the survey and *khasra*-writing have been kept separate.

It is not to be supposed that the extra work in preparing the *khasras* and *amabandis* has not entailed extra labour on the Survey; but all this has been cheerfully borne, in the hope of making the Cadastral Survey of still greater use to the North-West Provinces' Government which has all along seen the advantage of having good professionally prepared field maps that can be depended on.

That the Survey has been able to carry out successfully the combined work, has depended, however, on the cordial co-operation received from Mr. Porter, the Settlement Officer, and his staff. Had he not aided the Survey, and done his utmost to smooth away causes of delay, and made his establishment work in with the Survey in every way, the present results could not have been attained. In future it will have to be recognized as an axiom that in all combined work of this sort no success can be hoped for unless there is cordial co-operation between the Survey and Settlement Departments.

NAINI-TAL,
The 23rd July 1883.

W. BARRON, *Major*,
Deputy Superintendent, Survey of India,
In charge No. 4 Party, Revenue Branch.

No. 114, dated Naini-Tal, 16th August 1883.

From—MAJOR W. BARRON, Dy. Supdt. of Revenue Surveys, No. 4 Party,
To—The Deputy Surveyor-General, in charge Revenue Surveys.

IN continuation of my No. 102, dated 25th ultimo, I have now the honour to forward a copy of the note drawn up by Mr. F. W. Porter, C.S., Collector and Settlement Officer, Benares, regarding the working of the combined system of Survey and Settlement. I think his note shows that a satisfactory result has been attained.

I find from Smith's "Manual for Settlement Officers," Appendices IIIA and IIIB, pages 334 to 338, that the cost of Survey and Settlement in four districts cadastrally surveyed has been, per square mile :—

	Survey.		Settlement.		Total.
Agra	168	+	321	=	489
Hamirpur	253	+	252	=	405
Muttra	195	+	368	=	563
Moradabad	199	+	397	=	596

While, as far as Benares has as yet gone, the combined operations have cost—

Survey.		Settlement.		Total.
140	+	134	=	274

or only about one-half the cost of the two operations when conducted separately.

Of course the latter estimate does not include the cost of printing maps, but even when that is added to the cost of Survey the result will still be very favourable, and shows that the Survey, without adding to its own square mileage rate, has contributed to considerably reduce the rate for Settlement.

No. $\frac{36}{1-5}$, dated Benares, 13th August 1883.

From—F. W. PORTER, Esq., C.S., Settlement Officer, Benares,
To—The Officiating Commissioner, Benares Division.

I HAVE the honour to reply to your endorsement No. $\frac{2?1\cdot5}{1-20}$, dated 18th July 1883, forwarding copy of Board's No. $\frac{6\cdot5\cdot2}{1}$, dated 12th July 1883, calling for a further report on the system employed in this district in the preparation of the new Record-of-Rights.

The Board ask two questions :—

1*st*—Whether the system has been found so far successful.

2*nd*—Whether any alterations or improvements have been made in the procedure.

In answering the first question, there are two stand-points from which the system should be stated—(1) the Survey; (2) the Settlement. Major Barron's note (copy enclosed) deals with the question from the survey point of view, and, I submit, proves conclusively that, looked at in this light, the system has been a decided success. The secret of its success is the fact that by the two departments working together the attendance of the *zemindars*, tenants, and *putwaris* is secured. The record of holdings is consequently much more accurate, and *fields* are measured instead of *kiaris*. It will be seen that, owing mainly to the system employed, the average size of the field has risen from ·4 of an acre in Ghazipur and Ballia to ·83 of an acre in Benares. When it is considered that the effect of this increase in the size of the fields is to exactly halve the labour and expense of every subsequent operation, both in Survey and Settlement, the advantage of the system is obvious as regards both branches of the work.

From a purely settlement stand-point, too, the system has, I consider, been successful. This can best be tested by the work done and the expense incurred, the object of the system being to get the work done quickly, cheaply, and with as little friction as possible. The system, it must be remembered, was not fairly started till the commencement of the current year. I only arrived in Benares in the middle of November, and December was spent in teaching the men their work. They were started fair at the commencement of January, and since then, up to the end of June, the following work has been done :—

	Villages.	Number of fields.
Surveyed	851	315,934
Papers prepared in rough	851	315,934
Jamabandis and *khewats* attested by *munsarims* ...	654	233,364
Finally attested	199	79,436

Besides this, the papers of 150 villages have been arranged ready for fairing. The *jamabandis* in 110 villages have been notified, and the slips with areas entered distributed to the tenants.

I would note here in passing, that at the Conference in January last some anxiety was expressed lest a large number of disputes should crop up after this distribution of *jamabandi* slips. I then expressed my opinion that, if the attestation was carefully done in the first instance, this should not be the case, and my expectations have been fulfilled. Since the slips have been distributed, no fresh disputes have arisen, though there is no doubt the tenants have tested the correctness of the extracts furnished them, as in several instances errors of omission have been brought to light.

So far I consider the progress made under the new system has been satisfactory. The final attestation is now going on rapidly, and I hope by the commencement of the next working season to have the out-door work for the greater part of the Chaudauli records completed.

The next point is what this work has cost. The total expenditure on Settlement operations up to the end of July 1883, that is, including the June bills, has amounted to Rs. 18,301-10-4, composed of the following items :—

	Rs.	A.	P.
(1) Gazetted officers	1,750	0	0
(2) Fixed establishment	2,040	11	4
(3) Boundary work	3,150	15	10
(4) Preparation of records	7,665	8	2
(5) Tracing maps	856	12	11
(6) Purchase of tents	913	7	0
(7) Travelling allowance, tour charges, hot weather charges, and contingencies	1,275	11	5
(8) Stationery	500	15	8
(9) Cost of instruments	177	8	0
Total ...	18,301	10	4

Item 3 shows the expenditure in settling the boundaries previous to survey; items 6 and 9 are charges which will not recur. These three items, aggregating Rs. 4,241-14-10, should be deducted from the total expenditure, leaving Rs. 14,059-11-6 as the actual expenditure on the preparation of the Record-of-Rights.* I estimate the work done as about one-fourth of the *tahsil*, on which estimate the expenditure works out, in round numbers, at about Rs. 134 a square mile. Even taking one-fifth only as completed, the cost works out Rs. 170 a square mile, or about Rs 1,60,000 to Rs. 1,70,000 for the district.

These rates will, I think, compare favourably with the rates in other districts. So far, therefore, I venture to submit that the system has been successful both from a Survey and a Settlement stand-point, and has worked well both as regards the amount of work done and the expense incurred

Passing on to the Board's second question. No improvements or alterations of any moment have been found necessary in the procedure laid down in the joint note alluded to by the Board. Peculiar cases have occasionally cropped up, which had to be dealt with as they arose. This will always be the case, and no hard-and-fast rules can be laid down to meet every possible contingency.

Some few points in the system have, however, been taken exception to, and I should therefore like to take the opportunity of saying a few words thereon, more especially as the procedure, if considered a success, is likely to be prescribed for the preparation of the records in Gorakhpur and Basti.

It may be as well too to note any points on which difficulties have arisen, with the means used for overcoming them.

To understand the system thoroughly, it is necessary to explain the exact relative positions assigned to each paper forming the settlement record. These papers are five in number:—

(1) The map.
(2) The *khasra*.
(3) The *jamabandi*.
(4) The *khewat*.
(5) The "*halat dehi*," or village state.

The map is here the foundation; the other records the superstructure. Everything that appears in the map must find its appropriate place in the *khasra*, *jamabandi*, and *khewat*. All details regarding cultivating holdings and tenures have been given in the *jamabandi*, and all details of ownership in the *khewat*. The *khasra* is an index to all three. In the survey columns of the *khasra* are found the areas and description of every plot in the map. In the column of owner and cultivator in the *khasra* are found references to the number in the *khewat* and *jamabandi* where the details regarding each *zemindari* and cultivating holding are given. This system avoids endless repetition, and gets over the great difficulty of want of space in the *khasra*. For instance, given a village with three *pattis* composed of inter-mixed fields, with twenty sharers in each *patti*, it would be impossible to enter twenty names before each field in the *khasra*. In the *khewat* the *pattis* are all numbered serially, and full details of the *zemindari* body are given, the *khasra* merely containing the words "*zemindars of patti* so and so" as per "detail in *khewat* No. so and so." In the same way in the cultivator's column of the *khasra*, when there are two or more sharers in a cultivating holding, only one name is entered, and a reference for details is given to the *jamabandi* number on which the holding is entered. I have thought it necessary to explain this procedure at some length, as it has been called in question. Some people think it is necessary to enter the names of *all* the *zemindars* and *all* the tenants opposite each field in the *khasra*. My experience is that using the *khasra* simply as an index to the other papers in the way I have indicated saves a large amount of labour, and insures greater accuracy, inasmuch as the more names are repeated the more likelihood there is of error.

I take up the other points in the order they come in my first memorandum.

The Collector of Gorakhpur has, I believe, found some difficulty in preparing the "*hissa kushi*" or "*fard noiyat*," which is the first operation in the new system. I confess I cannot see what difficulty there is. The tenure of each village and *mahal* is easily ascertainable, whether it is *zemindari*, *pattidari*, or *bhayachara*; the names of the *zemindars* can also be found out. The measure of each *zemindar's* right is always either a fractional share (expressed in annas and pies or *bighas* and *biswas*), or the amount of land in his possession. All that is necessary is to record the nature of the tenure, with the names of the *thoks* and *pattis* into which the village is divided, and the names of the sharers. If the fractional shares representing each sharer's rights are obtainable, so much the better, but, if not, they can be entered afterwards. If the measure of each sharer's right is the amount of land he holds, this fact should be recorded. The area of land in each sharer's possession must come out when the *jamabandi* is attested, and will be entered in the attested *khewat* when the areas are obtained from the Survey. As far as my experience goes, there has as yet been no difficulty in ascertaining the details required.

All that is wanted is sufficient material to enable the *amin* and *patwari* to fill in the column of ownership in the *khasra*. If there is any dispute between the sharers in any particular *patti*, the difficulty is got over by entering the words "*zemindars of patti* so and so," as previously explained, and the dispute is taken up and settled by the Settlement

* *Note*.—There are 906 villages in the Chandauli *tahsil* with a total area, by last survey of, in round numbers, 268,000 acres = 420 square miles.

Deputy Collector when attesting the *khewat*. If the ownership of a field is disputed by the *zemindars* of two *pattis*, the column of ownership in the *khasra* is left blank, and the dispute is entered in the list of disputes for future settlement.

The Urdu *khasra* prepared by the survey *amin* has been hitherto retained, but I am inclined to cut it down somewhat in bulk. It is chiefly useful as a vehicle for the Survey to enter their areas in when worked out, so as to avoid papers passing from one department to another, more especially when the survey parties are in recess. I consider the details of caste, residence, length of tenure, &c., as superfluous in this paper, and propose, after consultation with Major Barron, to eliminate these details in the Urdu *khasra*, leaving of course all survey details, but entering in the columns of owner and cultivator only the name of the *thok* or *patti*, and the bare names of *zemindar* and cultivator. I think this would be sufficient. The entry of the other details only causes confusion, as disputes regarding them constantly arise at final attestation, which entail alterations after decision. The Urdu *khasra* being with the Survey Department cannot be altered at the time, and the two therefore differ. This would have given rise to many disputes had I not given an order that the Urdu *khasra* was to be considered as an authoritative document only, so far as the survey entries are concerned, all other entries being taken from the Hindi *khasra*. It is impossible to do away with the Urdu *khasra* entirely, as the settlement work would come to a stand-still if the Hindi *khasras* had to be sent to the Survey for filling in the areas. The old area book too is, I find, not quite sufficient for my purpose. By using a *khasra* form, with the same number of fields on each page as in the Hindi *khasra*, the settlement get the totals of each page in addition to the field areas and the village totals. This is useful for checking purposes, and is unobtainable from an area book.

A very large proportion of the disputes which have arisen at attestation have been with regard to cultivating tenures. There are two reasons for this:—(1st) the old records are on this point generally unreliable and often misleading; (2nd) the *zemindars* and tenants were taken unawares; they did not expect to be called upon to test the records so soon. Thinking that in the ordinary course of events the preparation of the Record-of-Rights would not have been commenced till next working season, they were, therefore, unprepared. Many *zemindars* threw into dispute every cultivator's tenure in estate after estate, and on being asked the reason said they were new purchasers, knew nothing of the tenures, and had not had time to look up the papers. In Chandauli, there was no remedy for this state of things, and the disputes have had to be taken up and settled. I was, however, determined that the same thing should not occur in the Benares *tahsil*. For the villages to be taken up next working season, each *putwari* has a triple extract in parallel columns from the F247F., 1270F., or 1269F., and 1289F. *jamabandi*. This shows the cultivator's tenure of each field at last settlement, 20 years ago, and last year. The *zemindars* and tenants will now have no excuse for disputing tenures. Of course this plan has not yet been practically tested, but I expect good results from it.

I have already noted that the distribution of *jamabandi* slips after entry of areas has not, as was anticipated by some, resulted in an influx of disputes.

There is but one other point to notice, and it is one which cannot be too strongly insisted upon. It is that, if the system is to be a success, the Settlement Officer and Survey Officer must work together. It is obvious that, if there is friction between the heads of the departments, there will be friction between the subordinates, and the work will suffer. At the commencement of the work Major Barron and I agreed that on all pure survey questions the Survey Officer's order was final, but on all points connected with the preparation of the records, the Survey Officer and his Assistants were to be looked on as Assistant Settlement Officers acting under the Settlement Officer. This rule simplified matters immensely.

A moment's thought will show how very much the Settlement Officer's hands are strengthened by this system. Under the old plan the Survey Officer and his five to seven assistants were literally wasted. They had only areas to test. Now the papers are prepared simultaneously with the Survey. The officers of the Survey Department can test the entries in the Record-of-Rights together with the areas. It simply comes to this, that under the present system the Settlement Officer has the aid of six or seven European assistants without one extra farthing of expense to the State. It may be said that these assistants know nothing of settlement work. This is true, but they can in a very short time pick up sufficient to enable them to test entries, which are all made according to fixed rules. At all events my experience is that they are a very considerable help, and I would wish to put on record my cordial acknowledgments for the valuable assistance rendered by Major Barron and his subordinates. There is no doubt that the new system relieves the Settlement by throwing an extra burden on the Survey. That the Survey were strong enough to take up the extra duties without detriment to their legitimate work is clear, but the readiness with which they have responded, and the willingness they have shown in taking up the extra work, is, I submit, to their credit.

Before concluding this somewhat lengthy note, I have at your request to make a few remarks on the question of entry of soils. The point does not, of course, affect this district, but is raised with regard to Gorakhpur and Basti. There are, it appears, to me two questions involved:—1st, the system of classification; 2nd, the agency to be employed in entering the soils.

The first question must, I would submit, be left entirely to the Settlement Officer. It is impossible to lay down a hard-and-fast rule as to the classification to be used. So much depends on the formation of a country and the system of rents. To some cases natural soils

would be applicable, as *doomat* (loam), *mattear* (clay), and *bhoor* or *bullooa* (sand). In other tracts the division would be into "*uparhar*" and "*tarhar*," or upland and lowland, while in others again the classification would be based on the position of the fields, as in the case of "*Gobind*," "*Manjha* and *Har*."

I would suggest that Settlement Officers be enjoined to use as simple a classification as possible, and to select the one most in accordance with the usages of the tract or pargana, and therefore most suitable as a means of check on, and comparison with, the existing rentals.

With regard to the agency, I would deprecate the use of the Survey staff for this work. I consider the entry of soil to be as much the duty of the Settlement Officer as the assessment itself. The main point to be aimed at in classification is to get all the same kind of soil in the tract or pargana entered under the same name; otherwise the classification is useless. It is impossible, I hold, to accomplish this with a large staff, as there are sure to be differences of opinion, and the same soil will be classified by different men under different names. I would keep the classification of soils quite separate from the preparation of record, and I would let the Settlement Officer make his own classification after the Survey have furnished the maps and *khasras*. The Settlement Officer could employ a small special staff of trained *munsarims* to do this work; for this classification as well as for the actual assessment the Assessing Officer should be personally responsible.

A copy of this note has been, according to your instructions, sent direct to the Board.

W. H. D'C.—Reg. No. 1036 I.—400—1074-84.

APPENDIX A.

MAJOR BAIRD'S REPORT

ON THE

VOLCANIC ERUPTIONS AT JAVA IN AUGUST 1883.

Report. by MAJOR A. W. BAIRD, R.E., *Deputy Superintendent 3rd Grade, in charge Tidal and Levelling operations, on the effects of the great terrestrial disturbances in the Straits of Sunda (Java) 27th August* 1883, *as recorded on the Self-registering Tide Gauges of the Survey of India.*

THE disturbances of the surface of the ocean, caused by the volcanic eruptions at Java in August last, are clearly recorded on the diagrams of the Self-registering Gauges at the various tidal stations along the east and the west coasts of India, and even as far as Aden.

The information thus afforded is of considerable scientific importance, more especially as regards the propagation of the so called "Tidal" waves.

The name "Tidal" waves has generally been given to the great ocean waves caused by an upheaval or subsidence of the sea at some locality where an earthquake shock or volcanic eruption has occurred. In the case of an upheaval, the resultant primary sea wave would be a "positive one", while a subsidence would cause a "negative wave"; in both cases the waves would be annular so long as their extension across the ocean was unfettered. These waves being independent of the tide, it is incorrect to term them "Tidal". They may be described more accurately as "Supertidal".

The term "Supertidal" wave.

Although the locality of the recent volcanic eruptions at Java—as far as the determination of the origin of the "Supertidal" waves—is sufficiently defined, the time of creation of the first of the great waves, or even of the first of the smaller ones, which preceded them, is not forthcoming in any account which has yet appeared. It is stated in one newspaper account (*Daily News*) that on Sunday evening 26th August "enormous "waves began to dash with greater force upon the shore", which implies that previous to that time *smaller* waves were observed. This account mentions the disappearance of a vast tract of country, in the early morning of the 27th August, and that "the waters of Welcome "Bay in the Straits of Sunda, of Pepper Bay on the east and of the Indian Ocean on the south, "had rushed in and formed a sea of turbulent waters."*

Locus of disturbances known, but time of commencement uncertain.

In addition to the precise details forthcoming from the diagrams of the Tide Gauges at the various stations, information has been obtained from the Port Officers at several other places in India and in Ceylon; which, although partially supplying connecting links in the chain, is of small weight compared to that recorded by the Tidal Gauges.

Reports of the tidal disturbances from various Port Officers and other officials.

A chart is given to illustrate the relative position of the various stations: and diagrams of the disturbed tidal curve, reduced from the original records, are given to indicate what actually took place at each spot, and at the same moment of time. For the latter purpose, all the hour lines of the diagrams, have reference to local Mean Time Port Blair, in the Andaman Islands, which is the most easterly locality of all the places at which the disturbances are noted in this report. Although, in some cases, small waves or ripples are clearly shown on the original diagrams, during the afternoon of the 26th August, it has been considered sufficient to include only two complete days' curves, *viz.*, from midnight 26–27th August (Port Blair time) to midnight 28–29th August.

Chart and diagrams illustrating report.

It is assumed that there will be no trouble in following the general rise and fall of the "true tidal curve", and for this purpose normal curves have been drawn (in blue) shewing what would probably have been recorded on the diagrams if there had been no tidal disturbance. These normal curves have been laid down by plotting the position of each H.W. (High Water) and each L.W. (Low Water) as taken from the Indian Tide Tables for 1883. In almost every case the predictions as given in the tables were very close to the actuals as measured from the diagram for one or two days previous to and after the tidal disturbances. A free hand curve was then drawn through each H. W. and L. W. to form the nondisturbed tidal curve. It will be observed that the normal curve at Beypore falls much below the actual curve: there was a freshet caused by having rainfall in the backwater, or creek at Beypore between the 26th and 29th August, and the general level of the water was thus raised quite irrespective of the tidal disturbance.

The longitudes of the several stations west of Port Blair in time are as under:—

Station.	*Long.*		*Station*	*Long.*	
	h	m		h	m
Kidderpore	0	18	Trincomalee	0	46
Diamond Harbour	0	18	Gallé	0	50
Dublat	0	19	Colombo	0	52
False Point	0	24	Beypore	1	8
Vizagapatam	0	38	Bombay	1	20
Madras	0	50	Kurrachee	1	43
Negapatam	0	52	Aden	3	21
Pámban	0	50			

* Since this report was written, important information has been received from H. M's. Consul at Batavia from which a very fair approximation of the time of origin of the great disturbance at Krakatoa has been calculated. See Addendum to this Report.

The original diagrams are recorded on various scales to suit the various ranges of the tide at different stations. The diagrams for illustrating this account have been prepared on an uniform scale for all stations.

No significant tidal disturbance at Amherst or Rangoon in Burma.

It is remarkable that there should be no indication of any sea wave at Rangoon, Amherst, or Moulmein on the Burma coast, but the tidal disturbance, consequent on the earthquake on the 31st December 1881, in the middle of the Bay of Bengal (which is described by the Surveyor General in the General Report of the Survey of India 1881-82) was not felt at these stations, and the Surveyor General surmised that it was "due to the "circumstance that the belt of islands and shoals which extends from Cape Negrais down "to the Island of Sumatra, forms a barrier to waves issuing from an origin near the centre "of the bay."

The tidal disturbance not recorded on the Self-registering Tide Gauge at Singapore.

It is even more remarkable that there was no trace of tidal disturbance on the diagram of the Self-registering Tide Gauge at Singapore. The Master Attendant at Singapore reports under date 27th October, "no tidal wave caused by the recent earthquake "was felt at Singapore: the tidal gauge—self-registering—kept at Singapore and watched "carefully day and night recording no difference whatever in the tide."

Order of reporting the details of disturbance.

Details of the disturbance will now be given as measured from the original diagrams, and as reported by the Port Officers, and they will be given in the following order. First, Port Blair, then Galle, Trincomallee, Pámban, Negapatam, &c., *i.e.* from the south to the north of the Bay of Bengal: afterwards Colombo, then Beypore, Bombay, Kurrachee and Aden, being in order along the west coast of India.

Great detail given from tidal diagrams.

At the stations where the Tide Gauges are working, the disturbances are reported in great detail, so that the facts will be available for the further treatment of the subject by more competent hands.

Style of recording the disturbances.

In recording the arrival of any wave at a tidal station, the time given is that at which the apex of the irregularity is recorded, when the "crest" is presumed to have reached the locality. Similarly the bottom of the "trough" is considered the time of appearance of any distinct depression. For the heights, the measurements are made from the preceding trough to the crest which follows, and, as far as possible where the irregularity takes place during a rise or fall of tide, due allowance has been made for that.

PORT BLAIR (TIDAL STATION).

Slight disturbances commence.

The disturbance appears to have commenced about 9·45 P.M., of the 26th August. During the slack water at that time, four (4) small waves about ½ of an inch in height appeared at intervals of about 20 minutes apart; in the following rising tide, the disturbance is certainly apparent, but in no case does an irregularity of as much as 1 inch appear in the curve. At the slack water about 4·30 A.M. of the 27th, there are numerous small waves of 1 inch in height at intervals of about 7 minutes. During the following falling tide, there are no irregularities of any consequence.

For the slack water at low tide at 11 A.M. of the 27th, the irregularities increase until at about noon a few waves 4 inches in height succeed each other at intervals of 45 minutes. Then we find a distinct depression of about 2 inches occurring at 1·12 P.M., followed by several great waves as follows:—

GREAT WAVES ...	No.	... ...	1.	2.	3.	
	Time (P. M.) ...	... ...	1h 55m	3h 12m	4h 8m	
	Interval	Rising tide ...		77m	51m	66m
	Height		15 inches	16½ inches	4½ inches	
	No.	... ...	4.	5.	6.	
	Time (P. M.) ...	... ...	5h 9m	5h 46m	6h 0m	
	Interval	Slack water high tide ...		37m	14m	20m
	Height		7 inches	4½ inches	6½ inches	

After which 28 minor waves of heights varying from 1 to 4½ inches appear at intervals of from 15 to 30 minutes.

At the slack water high tide on the morning of the 28th, the crests of 2 distinct waves having a height of about 5 inches appear at an interval of 1 hour and 12 minutes—the trough between the crests appearing at 6 A. M. These are succeeded by a series of minor waves varying in height from 1 to 3 inches. During the next falling tide the only noticeable irregularities are one wave 2 inches in height at 10·25 P.M. and another 1½ inches in height at 11 P.M.

At slack water low tide on the morning of the 29th, 4 waves of heights varying from 1 to 2½ inches appeared at intervals of 18 minutes. In the next rising tide the irregularities though apparent are insignificant. During the following falling tide, with the exception of 3 waves about 1 inch in height, which occurred at intervals of 18 minutes about 2 P.M., hardly any disturbance is apparent. There is a trace of disturbance at the succeeding high water at about 8 P.M. of the 29th, after which it may be considered to have entirely disappeared.

In connection with the foregoing, the following reports of the Port Officer, Port Blair, dated 4th September 1883, are interesting. It may be remarked here that there is no telegraph cable to Port Blair and consequently the intelligence of the Volcanic Eruption at Java could not have reached the Port Officer until the arrival of the next steamer from Calcutta, some considerable time after the date of his report.

Report by Port Officer, Port Blair.

"I have the honor to inform you that recently several reports were heard in Port Blair "resembling the firing of heavy guns. The steamer *Kwang-* "*tung* was sent round the coast to see if any vessel was in "distress, as it was supposed the guns were signals of distress from some ship which "had got into difficulties, no sign of any such disaster was however found. The weather "at the time, *i.e.* between the 27th and 29th August, was very unsettled and heavy "rain and wind prevailed. The chart on the drum of the tidal observatory shews con- "siderable disturbance between about 3-30 A.M. on the 27th August and 8 A.M. on the "29th, and the same was slightly torn; the water in the tank was also agitated, so much "so that I thought a hole had occurred below the sea level, and I sent for the Mechani- "cal Engineer to examine the tank, but it was found intact. Mr. Man informs me that "the tide at Dunny Leaf Creek at about 7 A.M. on Monday the 27th August, suddenly "receded and returned three times within a few minutes, leaving the dawk Dinghee high and "dry each time."

Noise of explosion.

"From these facts it would appear that what was taken for the firing of heavy guns, "must have been some atmspheric disturbance, and taken with the tidal phenomenon "observed. it would seem that shocks of an earthquake were the cause. I write to inform "you of these occurrences, as you may have heard of disturbances of this nature elsewhere, "and the information may be useful."

The Port Officer reported further on the 8th September, and both the reports were despatched by the same steamer from Port Blair. "In continuation of my letter No. 25, "dated 4th instant, I have the honor to inform you that by the return of the *Maharani* "from the Nicobars, information has been received from the officer in charge there that the "extraordinary sounds as of guns firing, and tidal disturbances were experienced there also "on the 26th and 27th August, but with greater violence, so much so that the people were "much alarmed and deserted their villages in terror. It is very evident that there has been "a severe earthquake somewhere and in all probability a cyclone."

The 3 waves at 7 A.M. at Dunny Leaf Creek, not recorded.

It is remarkable the 3 waves reported by Mr. Man at 7 A.M. of the 27th as having been so apparent at Dunny Leaf Creek (about 5 miles inland from Port Blair Tide Gauge) are not specially shewn on the diagram.

GALLE.

It is most unfortunate that a Self-registering Tide Gauge has not as yet been erected at Galle, which from a scientific point of view is perhaps the best locality for a tidal station in all India or Ceylon.

The Master Attendant in his report first expresses regret that there is no Self-registering Tide Gauge at work and then states :—"As it is although "there were 4 such 'waves' noticed in this Port as must "have resulted from this earthquake, I can but place before "you the action of one of them which I witnessed myself, but from enquiries made from "my people who witnessed the others as well as it, I should say it was in respect of length "of time of the disturbance and extent of recession of the water—a recurrence or repetition "of those waves which preceded it."

Official Report received from the Master Attendant.

"These occurred respectively at the hours of 1 (1-50 P.M. Port Blair time), "2 (2-50 P.M. Port Blair time), 3 (3-50 P.M. Port Blair time), and 4-30 (5-20 P.M. Port Blair "time) in the afternoon of the 27th August. It was the last which I witnessed and now "record as a most unusual receding of the sea. The small boats at their usual anchorage "being left by it, a thing I had never seen before during my tenure of office since 1860."

"It was about 1½ minutes in recession and then about the same time in a sort of "suspensary stand still, when it commenced quietly to rise again taking about the same "time 1½ minutes to reach the level of our highest high water marks. Thus making "from the lowest mark of recession, to it, a difference of 8 feet 10 inches. The usual "tidal rise and fall here is about 2 feet, and so the great difference caused by this distur- "bance was palpably from unusual recession."

Combining the above information with what is reported from Trincomalee, it seems most probable the arrival of the first great wave at Galle was somewhat later than reported by the Master Attendant, and is assumed to occur about 2–15 P.M. at both places.

Probable arrival of first great wave determined by comparison with Trincomalee report.

But, as will be shewn hereafter, the almost identical record of the great waves at Negapatam and Beypore, (the former to the north and the latter to the north-west of Galle, and at distances from it not very different), seems to shew conclusively, that, had a Tide Gauge been working at Galle, a very similar registration would have been shewn on its diagram.

Great waves at Galle most probably the same as at Beypore and Negapatam.

TRINCOMALEE.

Through the kindness of the Master Attendant, Trincomalee, the following information is available.

Extract from Report by Captain Whatley, R.E., to the Master Attendant, Trincomalee.

Captain Whatley writes to the Master Attendant as follows:— "I was sitting smoking a pipe in the Mess "verandah, which as you know is just over the sea, at about 1-30 (2-16 P.M. Port "Blair time) on a perfectly calm day, when my attention was drawn to a heave or "rush of the sea which foamed up against the fort wall below. It did not subside rapidly "but there was several minutes difference of time between the arrival of any two of the "waves. I had a party of workmen at the time digging at the sea wall foundations "near the fort gate; they reported that a wave rushed in eight times filling up their "excavations, I roughly calculated the height of the wave as 5 feet but then the water was "piled up just where I was, by rushing round the bay and meeting the reef at the corner."

Report by the Chief Clerk, R. E. Department, to Master Attendant.

"The following information received from the Head Mason of the R. E. Department, "who with his gang of workmen was engaged in building "up a sea-wall to protect the entrance road to Fort Frederick, "on the day the wonderful phenomenon took place and "personally witnessed the whole transaction, I give you for your guidance." * *

"The extreme rise 4 feet at an average.

" Ditto fall do. do.

"The number of times the wave appeared to come and go was about 13 times, of which "the 6th, 7th and 8th were those that caused more or less the extreme rise and fall above "stated, and the rest were of a kind not to attract so much the notice of the working men.

* * * * * * * * * * *

"The exact time was 1-30 P.M. (2-46 P.M. Port Blair time) on Monday the 27th "August 1883." * * * * * * * * * *

Report by the Signaller of Batticaloa Flag Staff. Noise of explosions heard.

The Signaller, Batticaloa Flag Staff, reports as follows:—"I beg to state that about "midnight on Sunday the 26th August, I heard about 5 or "6 times a noise similar to that of the noise of a cannon "being discharged at intervals of 15 minutes, I believe "towards the sea in the east. Very early in the morning I observed the cargo boats, that "were moored in the lake just opposite to Mr. Atkinson's bungalow, were on the move, but

Small waves at 10 minutes intervals early on morning of 27th.

"when I noticed this very closely I found the rise and fall "of water at intervals of 10 minutes, and the height of the "wave in the sea near the Bar rose in my opinion to about "8 feet, about noon on Monday, and in the lake it was about 3 feet high; and on Monday "morning too about 3 times I have noticed a noise similar to that of the discharge of a "cannon in the sea towards the east, and after the highest rise of the water at noon (0-46 P.M. "Port Blair time) no such noise was heard."

Extract from Report by Mr. Alfred Koch. Noise of explosions heard.

"For report on this I beg to state that on Sunday evening, the 26th August last, while "seated in the outer verandah of my bungalow in Kotaimunai, "I heard distinctly about 6 P.M. (6-46 P.M. Port Blair time) a "loud report as if a cannon was discharged down southward.

Small waves about 7 A.M., 27th August.

"The next morning, Monday 27th, on my way to the office about 7 A.M., near about the "Police station where there is a shoal, I noticed the water "receding rapidly, I stood for a while watching it, when a "cooley passing near me said, 'Sir, this is going on since last "night, water rising and falling'; and before I could walk round the causeway and reach the "Custom house, every dry spot in the lake was under water, just then the water must have "risen about 2 feet." * * * * * * * *

Great wave at 3-46 P.M.

"The rise and fall of water continued the whole of Monday at intervals of about 10 "minutes, the extreme rise and fall being about 2 feet each "time at about 3 P.M. (3-46 P.M. Port Blair time). Mon-"day I heard the noise of water rushing in with some force, and peeping through the window

Disturbance visible till about 10 A.M., 28th.

"I observed the water coming foaming near the causeway, "and this time the water rose fully 3 feet: the rise and fall "continued on Monday night too and was slightly percepti-"ble till about 10 A.M. (10-46 A.M. Port Blair time) Tuesday."

First great wave probably at 2-15 P.M.

From the above reports the arrival of the first great wave seems to be pretty well established as occurring at 2-15 P.M. Port Blair time, and probably the great wave recorded at 3-46 P.M. by Mr. Koch corresponded to the 3rd great wave reported at Galle.

2nd and 3rd great waves not observed.

It is curious that the 2nd and 3rd waves mentioned at Galle were not observed at Trincomalee, as evidently the disturbances were being pretty carefully noted at the latter port.

PÁMBAN.

The following is the official report received from the Port Officer at Pámban.

"To the north of the pass on the afternoon of the 27th August, the tide was not affected, but the look-out pilots stationed on the Island of Pulli, and on the south side of this island, report that about 3-45 (4-35, P.M. Port Blair time) the water first receded a long way past low water mark, then came up with a rush to about 1 to 2 feet above the usual high water mark, remaining so for about 4 minutes, then receded to return with less velocity and height, receded again and assumed its normal state. These pilots were stationed 3 miles from one another, and their reports tally so with one another, that I think faith can be put in them."

"I regret I am not able to report from actual personal observations, the only thing I remarked was the unusually strong current running through the pass from south to north."

NEGAPATAM (TIDAL STATION).

Slight disturbance commences.

The commencement of the tidal disturbance at Negapatam, as shewn on the diagram of the Self-registering Tide Gauge, appears to have occurred about 8-20 (9-12 P.M. Port Blair time) of the 26th August.

The crest of a small wave appeared about 1 hour and 35 minutes afterwards, the height of which was about 2 inches. During the following rise there is evidence of a disturbance. At slack water high tide at about 6-52 Port Blair time on the morning of the 27th, there are also numerous small irregularities. Similar irregularities are noticed during the following falling tide, and about the time of slack water low tide 6 small waves of heights varying from 1 to 3 inches are noticeable, after which a distinct depression occurs, the trough arriving at Negapatam at 2-2 P.M., the depth being about 4½ inches.

After this depression the great waves appeared.

27th P.M.	No.	1.	2.	3.	4.	5.	6.	7.	8.
	Time	3h 22m	4h 18m	5h 36m	6h 34m	7h 35m	8h 25m	10h 22m	11h 52m
	Interval		86m	48m	58m	61m	50m	117m	90m
	Height in inches	22½	22½	5½	1½	9½	5½	4½	5½
28th A.M.	No.	9.	10.	11.	12.	13.	14.	15.	
	Time	0h 45m	2h 13m	3h 54m	5h 44m	6h 10m	7h 27m	8h 57m	
	Interval		88m	101m	110m	26m	77m	90m	
	Height in inches	5½	10½	16	12	1½	6	2½	

Then during the following falling tide, there are 3 small waves, occurring at intervals of about 20 minutes, heights from 1½ to ½ inch. After which the following occur, and the waves are numbered as in succession to those noted previously.

28th P.M. and 29th A.M.	No.	16.	17.	18.	19.	20.	21.	22.
	Time	1h 1m	2h 12m	3h 40m	5h 30m	5h 57m	6h 32m	7h 25m
	Interval		71m	88m	110m	27m	35m	53m	19m
	Height in inches	5	6	8½	6½	3½	½	2½	
	No.	23.	24.	25.	26.	27.		
	Time	7h 44m	8h 42m	10h 25m	11h 50m	1h 31m		
	Interval		58m	103m	85m	101m		
	Height in inches	1½	1½	5½	4½	0½		

After this follow 3 minor waves, and the remaining disturbances during the rise are insignificant.

Then at slack water rising tide 6 minor waves occur, and during the succeeding falling tide only one significant irregularity (a wave crest ½ inch high) appeared at 9-52 A.M. of the 29th: at slack water low tide at 1-19 P.M. of the 29th, a wave 1½ inch high appears and is followed after an interval of 1 hour and 38 minutes by a second wave 4 inches high. During the following rise the disturbance though apparent is insignificant.

At slack water of the following high tide about 6-30 P.M. 2 waves each about 2½ inches high appear at an interval of about 1 hour and 10 minutes. After this the disturbances appeared to die out gradually, and to have ceased altogether after 4-30 A.M. of the 30th August.

PONDICHERRY.

Port Officer's Report.

M. le Capitaine de Port has forwarded a report stating that the surf (*le ressac*) is so great in the roadstead that no tidal disturbance was noticed. He forwards a statement by the 'Maitre du Port' at Carical

who says some "wavelets (*petites lames*) as if produced by a fresh breeze from the east "appeared about 2 o'clock on the morning of the 27th August," and this was considered by him very extraordinary as there was a dead calm at the time. From 6 A.M. to 11 A.M. the waves increased. With regard to the great waves the following is his report :—

Great waves.

"From 1 P.M. to 3 P.M. I have ascertained that they were about 2 feet (0·60 metre) in "height, and that the mean interval between them was 45 "minutes."

After this he reports that about 4 (4-52 P.M. Port Blair time) they got less and less, and during the night they only appeared to be the same as what was noticed at the commencement, and at about 11 A.M. of the 28th, they had completely disappeared.

MADRAS (TIDAL STATION).

The disturbance appears to be first appreciable about the slack water at low tide, noon of the 27th August.

The depression seems to have occurred at 2-10 P.M. Port Blair time of the 27th, after which the following may be noted in Port Blair time.

		Rising Tide.	*Slack Water High Tide.*	*Falling Tide.*	*Slack Water Low Tide.*
27th P.M. and 28th A.M.	Time	3h 23m	5h 17m 6h 38m	8h 23m 9h 50m	11h 10m 0h 17m
	Interval	114m	81m 105m	87m 80m	67m
	Height in inches ...	5	7½ 4½	3½ 2½	2½ 1½

		Rising Tide.			*Slack Water High Tide.*		
28th A.M. and P.M.	Time	1h 30m	3h 20m	4h 44m	5h 57m	7h 18m	8h 14m
	Interval	73m	110m	84m	81m	56m	96m
	Height in inches ...	3½	1½	2	2	2½	½
		Falling Tide.			*Slack Water Low Tide.*		
	Time	9h 50m	11h 5m		0h 35m	1h 59m	
	Interval	75m			84m		
	Height in inches ...	0	1½		3	2½	

After this the observations were unfortunately suspended as the Master Attendant did not know of the tidal disturbances at Java, and considered that something was wrong with the apparatus.

MASULIPATAM.

The following are two extracts from a Report of the Port Officer, Masulipatam.

Port Officer's Report.

"The flood on Sunday evening between 3 and 4 P.M. "came in with a tremendous rush similar to the Bore in the "Hooghly. Cargo boats waiting outside the bar with import cargo from S. S. *Bancoora* "were driven over the bar and landed on the sand bank inside notwithstanding they "were at anchor."

"On Monday the 27th we had a high tide and it came in as it did the day previously, only "the Bore was not so heavy."

COCONADA.

The Port Officer, Coconada, reports (dated 28th August) to the Master Attendant, Madras, as follows :—

Port Officer's Report.

"I have the honor to report that a tidal wave ran up the Coringa Bay and into the "Coconada River at about 6 o'clock last evening, the tide "was running ebb just previously, when it suddenly rose in "the river about 2 feet and shortly after receded with a strong ebb."

VIZAGAPATAM (TIDAL STATION).

The tidal disturbance (as shown on the diagram of the Self-registering Tide Gauge) appears to have commenced during the rising tide of the night of the 26th and morning of the 27th August.

At 2-15 (2-53 A.M. Port Blair time) of the 27th, there is a wave of 1 inch in height followed at an interval of half an hour by a second of equal height, the latter being succeeded at half an hour's interval by a third, the height of which is ¾ of an inch. During the slack water high tide, the following falling tide, the next slack water low tide and the succeeding rising tide, there is a succession of small waves following each other at short intervals of about a quarter of an hour, and the depression preceding the great wave appears to have occurred about 2-54 P.M. of the 27th.

After this comes the incidence of the first great wave, the crest of which may be considered to have arrived at 3-52 P.M., its height 12 inches; about the time of the arrival of the crest of this wave, there are 4 distinct small waves, at intervals of 7 minutes, and heights of from 1 to 1½ inches. The arrival of the crest of the next great wave is not well defined, but may be taken as 4-53 P.M., and its height 4 inches. But between these two waves there are two small waves at intervals of about 1¾ minutes, and heights about 2 inches. The crest of the third great wave may be considered to have arrived at 5-28 P.M., and its height may be taken as 5½ inches. The arrival of the fourth wave may be taken as 6-11 P.M., and its height 7½ inches; there are numerous intermediate waves of from 1 to 3 inches and at intervals of about 6 minutes, between the second and fourth great waves. The fifth and sixth waves may be considered to have arrived at 6-59 and 7-41 P.M., respectively, and their heights may be taken as 5 inches and 4 inches. It is impossible to distinguish the other great waves at Vizagapatam.

After this on the evening and night of the 27th, also during the whole of the 28th and until about 9 A.M. of the 29th, there is a succession of waves of various heights.

During the succeeding falling tide, no irregularities of more than an inch and a half are noticeable, there is a distinct depression at 1-24 P.M., amounting to 3 inches. At slack water low tide about 2-3, P.M. of the 29th August, there are 5 small waves of about 1 inch in height at intervals of from 15 to 20 minutes. During the following rising tide, the disturbance is quite apparent, but there are no irregularities greater than one inch. At the slack water high tide, the disturbance is still seen, but it appears to have gradually died away, and the last trace of the influence may be said to have been felt at 8-38 A.M. of the 30th August.

FALSE POINT (TIDAL STATION).

The time when the disturbance may be said to be noticeable, on the diagram of the Self-registering Tide Gauge, is about 1-30 (1-54 P.M. Port Blair time) of the 27th August, during a rising tide.

The depression may be taken as occurring at 3-42 (4-6 P.M. Port Blair time). After this the following may be taken in Port Blair time, the heights marked as 0 signifying cessations or pauses in the rising or falling of the tide, showing disturbances.

		Slack Water High Tide.		*Slack Water Low Tide.*	
27th P.M.	Time	5h 0m	7h 52m	10h 34m	
	Interval		172m	162m	
	Height in inches	10	15½	12½	
		Rising Tide.			
28th A.M.	Time	1h 42m	2h 41m	3h 42m.	4h 3m
	Interval		59m	61m	21m
	Height in inches	2	0	0	0

During the next falling tide there are 2 pauses, one at about 8-54 A.M., and the other at 9-54 A.M.

At slack water low tide on the afternoon of the 28th, 7 minor waves occur at intervals of about 27 minutes; during the next rise 2 slight pauses occur. At the following slack water high tide, 5 small irregularities including one pause are noticeable, and during the succeeding falling tide between 8 P.M. and 10-54 P.M., 4 small irregularities (including 2 pauses) occur. At the following slack water at 0-46 A.M. of the 29th, one wave 2½ inches in height occurs. After which the disturbance gradually disappears, the only remarkable feature being a depression of about 3½ inches at 8-24 P.M. of the 29th, during the slack water at high tide.

DUBLAT (TIDAL STATION).

The disturbance at Dublat, as indicated by the Self-registering Tide Gauge, may be said to have commenced at slack water high tide about 4-0 (4-19 A.M. Port Blair time) of the 27th August, when numerous small waves (heights of about 1 inch) occur at intervals of from 5 to 10 minutes. One noticeable wave (height 2¼ inches) occurs at 5-23 (5-42 A.M. Port Blair time). During the succeeding falling tide the disturbance is hardly apparent. At the following rising tide 4 pauses and 3 small waves about ¼ inch in height are noticed. The trough of the depression reached Dublat at 5-18 (5-37 P.M. Port Blair time) of the 27th, after which the following principal disturbances are recorded.

		Slack Water Low Tide.		*Falling Tide.*			
27th P.M.	Time	6h 14m	7h 6m	8h 10m	9h 19m	10h 13m	
	Interval		52m	64m	69m	54m	73m
	Height in inches	14	5	2	9	1½	

		Slack Water Low Tide.		*Rising Tide.*	
27th P.M. and 28th A.M.	Time	11h 26m	0h 31m		1h 43m
	Interval	65m		72m	
	Height in inches ...	3	7		6

During the rest of the rise there is only one noticeable feature at 4-49 A.M. of the 28th, of 2 inches. At slack water high tide the following may be noticed.

		Slack Water High Tide			
28th A.M. ...	Time	6h 7m	6h 46m	7h 19m	7h 43m
	Interval	39m	33m	24m	
	Height in inches ...	2	5	1	2

During the following falling tide, there are one or two small irregularities which need not be noticed.

At slack water low tide and during the succeeding rising tide, on the afternoon of the 28th, there are a few small irregularities.

The disturbance becomes very marked at slack water high tide about 7-19 P.M. of the 28th, when the following may be noted.

		Slack Water High Tide.							
28th P.M.	Time	6h 53m	7h 4m	7h 19m	7h 31m	7h 46m	8h 4m	8h 16m	8h 25m
	Interval	11m	15m	12m	15m	18m	12m	9m	
	Height in inches ...	4	½	3	2	2½	3	2½	½

During the next fall there is a distinct wave at 9-31 P.M., height 4 inches. The disturbance may be said to gradually die out, but it is still perceptible at the slack water of the low tide about 1-19 A.M., and in the slack water of the succeeding high tide at 7-45 A.M. of the 29th August.

DIAMOND HARBOUR (TIDAL STATION).

The disturbance as shewn on the diagram of the Self-registering Tide Gauge is traceable during the rising tide, between 2-0 (2-18 P.M. Port Blair time) and 7-0 (7-18 P.M. Port Blair time) of the 27th August. The first remarkable feature is the depression of 5 inches at 7-30 (7-48 P.M. Port Blair time) this is followed by a rise of 12 inches at 8-5 (8-23 P.M. Port Blair time). During the next falling tide there are 2 distinct bends in the curve, occurring at 9-6 (9-24 P.M. Port Blair time) and 11-33 (11-51 P.M. Port Blair time) which probably coincide with the crests of 2 waves.

During the succeeding rising tide, 3 similar bends occur at 2-45 (3-3 A.M. Port Blair time), 5-0 (5-18 A.M. Port Blair time) and 6-45 (7-3 A.M. Port Blair time) of the 28th August. These probably coincide with the troughs of waves. Similar slight disturbances are traceable in the next falling tide, and even as far as the low tide about 4 A.M. of the 29th August.

KIDDERPORE (CALCUTTA TIDAL STATION).

There is a slight disturbance as shewn on the diagram of the Self-registering Tide Gauge about 5–30 (5–48 P.M. Port Blair time) of the 27th August, but the only noticeable feature at Kidderpore is the depression occurring at 9–44 P.M. of the 27th, followed by a wave 6 inches in height at 10–18 P.M., evidently corresponding with the similar depression and rise during high water at Dublat and Diamond Harbour.

COLOMBO.

Extract from the Report of the Master Attendant.

The Master Attendant at Colombo reports as follows:—"I find it difficult to get at the "exact hour of the commencement of the tidal disturbance "in this harbour, but I am informed by the man in charge "of the landing jetty that about 2–30 P.M. of the 27th "August, there was a sudden rise of the sea to about 15 inches above the highest spring "tide and that shortly afterwards within 15 minutes, the sea fell to about 3 feet below the "lowest spring tide. I witnessed between 3–30 and 4–30 P.M. 4 rises and falls of the sea, "and as near as I can judge there were 7½ feet between the highest point to which the sea "rose and the lowest point to which it fell. During this time there was a strong current "in the harbour which carried away the stern moorings of some of the steamers in port and "swung them round against the wind. The tidal disturbance went on more or less till 8 P.M. "of the 27th, and I observed it again the next day about mid-day, but the rise and fall of "the tide then did not exceed one foot."

CAPE COMORIN AND PLACES IN THE VICINITY.

Extract from the Diary of the Superintendent, Light-house at Muttam.

KADIAPATAM.—Sea fell sufficiently to call for remark that the tide was low; but nothing more.

MUTTAM.—The fall was several feet, probably near 10, rocks never before known to be uncovered were left quite exposed.

PULLIANTOPE.—The sea receded about one hundred feet, while at

RAJAKAMANGALAM it is estimated at over two hundred feet, increasing in the direction of CAPE COMORIN where the sea receded for a very long distance, variously estimated at one to two miles. The fall was so sudden as to leave large fish floundering on the sandy bottom. In about quarter of an hour the sea returned in one wave and everything resumed its normal position.

BEYPORE (TIDAL STATION).

The disturbance, as shown on the diagram of the Self-registering Tide Gauge, may be said to have commenced at slack water high tide at 6.36 (7-44 A.M. Port Blair time) of the 27th August, when an irregularity (height one inch) is noticed. After this the following may be noted in Port Blair time.

			Falling Tide.				*Slack Water Low Tide.*		
27th A.M. and P.M.	Time	9h 56m	10h 38m	11h 29m	0h 4m	1h 9m	2h 6m	2h 38m
	Interval	42m	51m	35m	69m	30m	
	Height in inches	½	½	2	½	2	3	1

There is a distinct depression at 4-20 P.M. of 1½ inches. These are followed by great waves, *viz* :—

27th P.M.	No.	1.	2.	3.	4.	5.
	Time	4h 54m	6h 3m	6h 46m	7h 50m	8h 56m
	Interval	69m	43m	64m	66m	
	Height in inches	14½	8½	2	13½	10½

Then follows a small wave at 9-23 P.M., with a height of ½ inch.

27th P.M. and 28th A.M.	No.	6.	7.	8.	9.	10.	11.	12.
	Time	10h 41m	11h 44m	0h 29m	0h 50m	1h 32m	2h 41m	3h 23m
	Interval	63m	45m	21m	42m	69m	42m	51m
	Height in inches	13½	11½	1½	1	13½	14½	3
	No.	13.	14.	15.				
	Time	4h 14m	5h 14m	5h 43m				
	Interval	60m	29m					
	Height in inches	15	7	6				

Then follows the largest wave at 6-38 A.M., height 2 feet 6 inches.

28th A.M. and P.M.	No.	16.	17.	18.	19.	20.	21.	22.
	Time	7h 41m	8h 47m	9h 23m	10h 29m	11h 16m	0h 15m	0h 44m
	Interval	66m	36m	66m	46m	60m	29m	59m
	Height in inches	8½	14	3	4½	2	8	1½
28th P.M.	No.	23.	24.	25.	26.	27.	28.	
	Time	1h 43m	2h 8m	3h 18m	4h 29m	5h 26m	6h 13m	
	Interval	25m	70m	71m	57m	47m	73m	
	Height in inches	2	12½	11½	8½	2	5½	
	No.	29.	30.	31.	32.	33.	34.	
	Time	7h 25m	8h 8m	8h 38m	9h 32m	10h 13m	11h 13m	
	Interval	43m	30m	54m	41m	60m		
	Height in inches	10½	5	1½	3½	6½	6½	

After which the following disturbances may be noted.

29th A.M. and P.M.							
No.	35.	36.	37.	38.	39.	40.	41.
Time	0h 18m	1h 23m	2h 30m	3h 14m	4h 11m	5h 18m	6h 24m
Interval		65m	67m	44m	57m	67m	66m
Height in inches	3	1¼	1½	1½	3½	6	10½
No.	42.	43.	44.	45.	46.	47.	48.
Time	7h 44m	9h 13m	10h 27m	11h 59m	1h 9m	2h 23m	3h 8m
Interval		89m	74m	92m	70m	74m	45m
Height in inches	9	9	7	2	4	½	½

29th P.M.				
No.	49.	50.	51.	52.
Time	4h 8m	5h 8m	5h 46m	7h 8m
Interval		60m	38m	82m
Height in inches	3½	1½	2½	3½

During the next slack water high tide the following may be noted.

Slack Water High Tide.

29th P.M. and 30th A.M.						
Time	8h 23m	9h 8m	9h 44m	10h 38m	11h 32m	0h 13m
Interval		45m	36m	54m	54m	41m
Height in inches	3½	1½	2½	2½	1	2½

During the next falling tide the irregularities are not apparent.

At slack water low tide, 2 waves occur at an interval of about 50 minutes, the first 3½ inches and the second 1 inch in height.

During the following rising tide, one wave occurred at 7-29 A.M. of the 30th, height 3 inches.

Slack Water High Tide.

Time	10h 23m	11h 26m	0h 41m	
Interval		63m	75m	
Height in inches	2	5½	3	

At the next slack water low tide, 2 waves occur at an interval of 1 hour 25 minutes, and height about 3 inches.

The apex of the next high tide occurs at 11-8 P.M. of the 30th, when a wave of 9 inches in height appears to occur. After this the disturbance may be said to die away gradually, but it is not apparent when it entirely ceased.

BOMBAY (TIDAL STATION).

The first faint trace of a disturbance, as shewn on the diagram of the Self-registering Tide Gauge, occurs at 5-15 (6-35 A.M. Port Blair time) of the 27th August. At slack water high tide about 7-0 (8-20 A.M. Port Blair time) of the same day, a distinct disturbance is noticeable, and a second still more marked at 1-0 (2-20 P.M. Port Blair time) when 11 small waves of about half an inch in height occur at intervals of about 10 minutes.

During the next rising tide, there are 6 small waves at intervals of about 10 minutes and height about 1 inch, between 5 and 6 P.M., for which time, the water appears to have remained at almost the same level.

Then follows a distinct depression at 6-3 (7-23 P.M. Port Blair time) after which the water rose very rapidly, and the crest of the first wave may be taken as at 6-48 (8-8 P.M. Port Blair time) and the height may be taken as 10 inches.

The following may now be noted in Port Blair time.

Falling Tide.

27th P.M.							
Time	8h 20m	8h 26m	8h 38m	8h 50m	8h 59m	9h 17m	
Interval		6m	12m	12m	9m	18m	12m
Height in inches	1	½	½	2½	2	1	
Time	9h 29m	9h 41m	9h 47m	9h 54m	10h 3m		
Interval		12m	6m	7m	9m		
Height in inches	1½	1	½	½	1		

Although minute disturbances are apparent during the next falling tide, nothing remarkable is noticeable until slack water low tide about 2-20 A. M. of the 28th, when 10 waves occur at intervals of about 20 minutes and of heights varying from 1 to 2 inches. A disturbance still continues during the next rise of the tide, but the irregularities are exceedingly small, until the time of high water, when 4 distinct waves of from 2 to 3 inches in height occur at intervals of 20 minutes. During the next falling tide the irregularities are hardly appreciable. At low water about 3-50 P.M. of the 28th, the irregularities are again more marked, and during the next rising tide there is a distinct disturbance at 6-35 P.M. At the slack water high tide, there are 6 waves of from 1 to 2 inches in height at intervals of about 20 minutes. The disturbance gradually disappears, but is still slightly apparent at the slack waters of high and low tides as late as 5+0 P.M. of the 29th.

KURRACHEE (Tidal Station).

The disturbances, as shewn on the diagram of the Self-registering Tide Gauge, appear to have commenced about 6-0 (7-43 A.M. Port Blair time) of the 27th August, when numerous small waves at intervals of about 10 minutes occurred, and this continued up to about 5+0 (6-43 P.M. Port Blair time). After which the following may be noted in Port Blair time.

Slack Water High Tide.

27th P.M.	Time	4^h 58^m		5^h 18^m		5^h 28^m		5^h 46^m	5^h 58^m
	Interval		20^m		10^m		18^m	12^m	15^m
	Height in inches	1½		2		1½	1	1½	
	Time	6^h 13^m		6^h 34^m		6^h 46^m		6^h 59^m	
	Interval		21^m		12^m		13^m		
	Height in inches	1		2½		½		2	

After this a distinct depression occurred. The trough arriving at 7+37 P.M. and the dip may be taken as 6 inches. After which the first great wave appeared, and the irregularities may be noted as under:

		Slack Water High Tide.				*Falling Tide.*			
27th P.M.	Time	8^h 17^m		8^h 34^m		8^h 55^m	9^h 6^m	9^h 15^m	9^h 26^m
	Interval		17^m			21^m	9^m	21^m	22^m
	Height in inches	12½		2		4½	1½	2	4½
		Falling Tide.							
	Time	9^h 48^m		10^h 17^m		10^h 40^m	11^h 7^m	11^h 28^m	
	Interval		29^m		23^m		27^m	21^m	
	Height in inches	2½		2½		1½		4	
		Slack Water Low Tide.							
28th A.M.	Time	0^h 43^m		2^h 11^m		2^h 28^m	2^h 50^m	3^h 8^m	
	Interval		88^m		17^m		22^m	18^m	21^m
	Height in inches	11		11		2	1	1	
		Rising Tide.							
	Time	3^h 29^m		3^h 52^m		4^h 13^m	4^h 37^m	5^h 1^m	
	Interval		23^m		21^m		24^m	24^m	30^m
	Height in inches	1		½		1½	2	½	
	Time	5^h 31^m		5^h 52^m		6^h 4^m	6^h 13^m	6^h 21^m	
	Interval		21^m		12^m		9^m	8^m	37^m
	Height in inches	½		2		1	1½	1½	
	Time	6^h 58^m		7^h 10^m		7^h 30^m	7^h 58^m	8^h 11^m	8^h 21^m
	Interval		12^m		20^m		28^m	13^m	10^m
	Height in inches	1½		2		2	1½	1	1

At the slack water high tide one distinct wave occurs at 9-10 A.M., height 10½ inches.

Falling Tide.

Time	9h 58m	10h 16m	10h 29m	10h 59m	11h 17m	
Interval	18m	13m	30m	18m	21m	
Height in inches	3	2½	1	¼	6	
Time	11h 38m	11h 56m	0h 16m	0h 30m	0h 54m	1h 15m
Interval	18m	20m	14m	24m	21m	
Height in inches	3	1½	1	3½	4	1

Slack Water Low Tide.

28th A.M. and P.M.

Time	2h 7m	2h 37m	3h 6m	3h 29m
Interval	30m	29m	23m	
Height in inches	1½	3½	2	4

Rising Tide.

Time	4h 52m	5h 15m	5h 34m	5h 43m	6h 3m	6h 19m	6h 40m
Interval	23m	19m	9m	21m	15m	21m	
Height in inches	1½	¼	¼	3½	2½	4	¼

Slack Water High Tide.

Time	7h 4m	7h 29m	7h 52m	8h 21m	8h 43m	9h 5m	9h 30m
Interval	25m	23m	29m	22m	22m	25m	
Height in inches	1½	3	6½	7½	¼	2½	2½

During the following falling tide, the irregularities though apparent are too small to be noted. At the slack water low tide there is one distinct wave at 2-3 A.M. of the 29th, height 2 inches.

The irregularities during the next rising tide are still apparent but very small, and after this they may be considered to have gradually died out.

ADEN (TIDAL STATION).

The first disturbance, as shewn on the diagram of the Self-registering Tide Gauge, may be considered to have occurred at the high water about 3·0 (6·14 P.M. Port Blair time) of the 27th August, after which followed some small irregularities. The depression appears to have occurred at 5·22 (8·33 P. M. Port Blair time). After which the following may be noted in Port Blair Time.

Falling Tide.

27th P.M.

Time	8h 57m	9h 59m	10h 51m	11h 59m
Interval	62m	52m	68m	
Height in inches ...	½	1½	3	2

Slack Water Low Tide.

28th A.M. ...

Time	1h 6m	3h 51m	4h 11m
Interval	43m	20m	
Height in inches ...	½	1½	1

Rising Tide.

28th A.M. ...

Time	3h 12m	3h 43m	5h 16m	6h 31m	6h 59m	7h 16m
Interval	31m	96m	73m	28m	17m	
Height in inches ...	1	1	¼	¼	3½	½

At slack water high tide 1 wave may be said to occur at 9-6 A.M., height 1½ inches.

Falling Tide.

28th A.M. and P.M.

Time	10h 19m	11h 14m	0h 1m	1h 23m
Interval	52m	50m	82m	
Height in inches ...	3½	¼	2	3

At slack water low tide 1 very distinct wave occurs at 2-46 P.M., height 8¾ inches.

			Rising Tide.					*Slack Water High Tide.*		
28th P.M.	Time	... ...	4h 17m	5h 46m	6h 44m			7h 29m	8h 45m	
	Interval	... ...		89m	58m			76m		
	Height in inches	...	4½	2	3			6	9½	
			Falling Tide.					*Slack Water Low Tide.*		
28th P.M. and 29th A.M.	Time	... ...	9h 35m	10h 26m	11h 33m	0h 11m		2h 32m	3h 41m	
	Interval	... ...		47m	67m	38m			69m	
	Height in inches	...	3¾	1½	1	¼		0	10½	
			Rising Tide.					*Slack Water High Tide.*		
29th A.M. and P.M.	Time	... ...	4h 53m	5h 53m	6h 46m			9h 41m	10h 44m	
	Interval	... ...		60m	53m			63m		
	Height in inches	...	1	¼	1			6	5	
			Falling Tide.					*Slack Water Low Tide.*		
	Time	... ...	11h 37m	0h 39m	1h 35m			2h 39m		
	Interval	... ...		62m	56m	64m				
	Height in inches	...	2½	2¼	1½			4		
			Rising Tide.					*Slack Water High Tide.*		
29th P.M. and 30th A.M.	Time	... ...	4h 19m	5h 29m	6h 26m	7h 32m	8h 17m	8h 59m		
	Interval	... ...		70m	57m	66m	45m	42m	60m	
	Height in inches	...	¼	2	1½	1	1½	1		
			Falling Tide.							
	Time	... ...	9h 59m	11h 5m	11h 59m	1h 5m				
	Interval	... ...		66m	54m	66m				
	Height in inches	...	0	1½	1	0				

After this the disturbance may be said to have gradually died out, but there are still traces of it as late as 5-1 P.M. of the 30th.

In the following remarks the distances referred to are in *statute* miles.

Negative wave preceding the first great wave.

The depression or trough of the "negative" wave, which preceded the first great "positive" wave, appears to have arrived at the various stations as follows:—27th August.

East Coast.

	h m		h m
Port Blair	1 12 P.M.	False Point	4 6 P.M.
Negapatam	2 2 „	Dublat	5 37 „
Madras	2 10 „	Diamond Harbour ...	7 48 „
Vizagapatam	2 54 „	Kidderpore	9 44 „

West Coast.

	h m		h m
Beypore	4 20 P.M.	Kurrachee	7 37 P.M.
Bombay	7 23 „	Aden	8 33 „

Velocity across the open sea not obtainable as time of arrival at Galle is not defined.

It is difficult to arrive at any definite rate; for the velocity of the "negative" wave across the open sea, as we have no indication of its arrival at Galle, and it would be useless to compare the times of arrival at Beypore and Aden, because the wave in its progress to Beypore was obviously bent at Galle and its contour changed, and thus the unfettered portion had probably reached a locality much further west, before the wave was felt at Beypore.

Velocity along the east and west coasts of India.

Accepting 294 miles as the distance from Vizagapatam to False Point, and 630 from Beypore to Bombay, we obtain velocities of 3·23 miles and 3·44 miles per minute, respectively, for the velocities along the east and west coasts of India.

It is difficult to make a comparison of the smaller disturbances preceding the great waves at the various stations, but the following statement shews the irregularities at times which are not very dissimilar, taking into account the distances from the origin of disturbance.

The smaller irregularities at the commencement of the tidal disturbances.

Slack Water Low Tide, 27th August.

Station		Approximate Time	Average interval of Waves	Average Height
Port Blair		Noon	16 minutes	3 inches
East Coast	Negapatam ...	„	24 „	2 „
	Vizagapatam ...	„	16 „	1 „
	Dublat ...	Intervals uncertain, but irregularities quite apparent ...	...	...
West Coast	Beypore ...	After noon	45 minutes	2 inches
	Bombay ...	„	10 „	1 „

From the above it would appear that the heights of the small waves and their intervals diminished as the distance from the origin increased.

Small disturbances decrease in height as distances from origin increase.

In comparing the principal disturbances at the various stations, a very marked resemblance is seen between the diagrams at Negapatam and Beypore.

Comparison between the great waves at the several stations.

At Negapatam, from its relative position to the Straits of Sunda, we should expect to find a correct record of the "Supertidal" waves, before they were distorted in their course, or modified in their height by the coast line.

The following table shows the comparative times of arrival of the crests, intervals, and heights of the first 12 great waves (as far as they are recorded) at the various stations.

The Madras record shows the tidal curves much less distorted than at Negapatam and yet the incidence of the first wave at both places is fairly accordant as regards time, shewing that the course of the wave was nearly perpendicular to the coast line between those two places.

Peculiarity of the Madras record.

The less marked distortion at Madras may be attributed to the Tide Gauge there having been purposely constructed (on account of the surf) so as to be less sensitive than those at other stations.

The 2nd wave at Madras appears to come just between the 2nd and 3rd at Negapatam, while the 3rd agrees with No. 4 at the latter port. No. 4 is coincident with No. 6 at Negapatam, but No. 5 at Madras occurs before No. 7 at Negapatam.

The 2nd, 3rd and 4th waves at Madras, &c.

The waves shown at False Point appear very peculiar: the 2nd would seem to be a combination of Nos. 2, 3 and 4 at Negapatam, and it is to be remarked that it occurs at the slack water of low tide at False Point.

Waves at False Point.

The Dublat waves appear tolerably consistent with those at Negapatam, and it appears as if the waves came right up the centre of the Bay to arrive at Dublat.

Dublat waves more coincident than those at False Point with waves at Negapatam.

The 1st waves at Diamond Harbour and Kidderpore are most marked and have precisely the same form as at Dublat, occurring at all these places about the time of slack water high tide.

The first waves at Diamond Harbour and Kidderpore.

A great similarity exists between the waves at Beypore and Negapatam. But there is one very great wave at the former port which occurred at 6·38 A.M. with a height of 30 inches which is most remarkable and this is not so marked at Negapatam.

The great wave of 2 feet 6 inches at Beypore.

It is remarkable that the first 3 waves at Beypore are less in height than those at Negapatam, while No. 4 wave and all the rest except No. 11 are much greater at Beypore than at Negapatam.

Height at Beypore at first less but after the 3rd wave greater than at Negapatam.

The arrival of the first wave at Galle has been accepted as 2·15 P.M., *i.e.* 1 hour and 7 minutes before its arrival at Negapatam, and 2 hours 39 minutes before it reached Beypore: or 1 hour and 53 minutes before a mean between the times of Negapatam and Beypore.

Arrival of great waves at Galle, &c.

The arrival of the succeeding waves at Galle have been computed by taking 1 hour and 53 minutes from the means between the times at Negapatam and Beypore.

TABLE showing the Times of arrival and Heights of the first twelve Great Waves at the various stations, on the 27-28th August 1883. (Port Blair Time).

STATIONS		Wave No. 1	Interval	Wave No. 2	Interval	Wave No. 3	Interval	Wave No. 4	Interval	Wave No. 5	Interval	Wave No. 6	Interval	Wave No. 7	Interval	Wave No. 8	Interval	Wave No. 9	Interval	Wave No. 10	Interval	Wave No. 11	Interval	Wave No. 12	REMARKS.
		P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	h. m.	m.	h. m.	m.	h. m.	m.	h. m.	
Port Blair	Time	1 55		3 12		4 3		5 9		6 0		6 55		7 14		...	...	...	...	...	...	...	...	...	After No. 7 the waves do not correspond with those at Negapatam. Three small waves, height 1½, 2¾ and 2½ inches occurring at 5-46, 6-20 and 6-36 P.M., respectively, have not been taken into account.
	Height in inches	15	77	16½	51	4¾	66	7	51	6½	55	3¾	19	2½		...		...		...		...		...	
Gallo	Time	2 15																							
	Height in inches	?																							
Trincomalee	Time	2 15																							
	Height in inches	?																							
Pámban	Time	4 35																							
	Height in inches	?																							
Negapatam	Time	3 22		4 48		5 36		6 34		7 35		8 25		10 22		11 52		A. M. 0 45		A. M. 2 13		A. M. 3 54		A. M. 5 44	
	Height in inches	22½	86	22¼	48	5½	58	11	61	9¼	50	5¼	117	4½	90	5½	53	5½	88	10½	101	15	110	12	
Cartal	Time	3 22																							
	Height in inches	24																							
Madras	Time	3 23		5 17				6 38		...		8 23		9 50		11 10		0 17		1 30		3 20		4 44	
	Height in inches	5	114	7½			81	4¾	105	...		3½	87	2½	80	2½	67	1½	73	3½	110	1½	84	2	
Coconada	Time	...		...		...		6 46?																	
	Height in inches	...		...		...		2¾																	
Vizagapatam	Time	3 52		5 28		6 11		6 59	...	8 2	...	8 50	...	10 58	...	...	...	...	...	...	...	...	...	...	One wave at 4-53, height 4 inches not included here. The waves after No. 7 are not sufficiently defined to recognize their correspondence with those at Negapatam. The remaining waves do not correspond with those at Negapatam.
	Height in inches	12	96	5¼	43	7½	48	5	63	2½	48	3¾	128	1		...		...		...		...		...	
False Point	Time	5 0		...		...		7 52	...	...	...	10 34	...	...		A. M. 1 42		...		...		...	...	...	
	Height in inches	10	...	...		...		15¾	...	...	...	12¼		...		2		...		...		...		...	

TABLE showing the Times of arrival and Heights of the first twelve Great Waves at the various stations, on the 27-28th August 1883. (Port Blair Time).—(Continued).

STATIONS	Wave No. 1	Interval	Wave No. 2	Interval	Wave No. 3	Interval	Wave No. 4	Interval	Wave No. 5	Interval	Wave No. 6	Interval	Wave No. 7	Interval	Wave No. 8	Interval	Wave No. 9	Interval	Wave No. 10	Interval	Wave No. 11	Interval	Wave No. 12	REMARKS
	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	P. M. h. m.	m.	A. M. h. m.	m.	A. M. h. m.	m.	A. M. h. m.	m.	A. M. h. m.	m.	A. M. h. m.	m.	A. M. h. m.	
Dublat ... Time ...	6 14	...	7 6	...	8 10	...	9 19	...	10 13	...	11 26	...	1 43	...	...	...	...	...	4 49	...	6 46	...	...	Two waves, one of 7 inches at 0-31 and one of 2 inches at 6-7, have been neglected.
Dublat ... Height in inches ...	14	52	5	64	2	69	9	54	1½	73	3	137	6	...	...	...	...	...	2	117	5			
Diamond Harbour. Time ...	8 23	61	9 24	...	...	...	11 51	...	...	...	...	...	3 3	...	...	...	5 18	105	7 3					
Diamond Harbour. Height in inches ...	12		0		...		0		...		...		0		...		0		0					
Kidderpore ... Time	10 18																							
Kidderpore ... Height in inches ...	6																							
Gallo ... Time	2 15																							
Gallo ... Height in inches ...	?																							
Colombo ... Time	3 22																							
Colombo ... Height in inches ...	15																							
Beypore ... Time	4 54	69	6 3	43	6 46	64	7 50	66	8 56	105	10 41	63	P. M. 11 44	108	1 32	69	2 41	93	4 14	60	5 14	84	6 38	
Beypore ... Height in inches ...	14¾		8¾		2		13½		10½		13¼		11¾		13¾		14½		15		7		30	
Bombay ... Time	8 8	51	8 59	42	9 41	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	No other particular waves can be traced at Bombay.
Bombay ... Height in inches ...	10		2		1		...		...															
Kurrachee ... Time	8 17	...	9 26	...	10 17	50	11 7	...	A. M. 0 43	88	A. M. 2 11	...	A. M. 2 50	...	...	...	...	...	...	...	...	...	...	The remaining waves are very small. Three waves, height 4½, 2½ and 4 inches at 8-55, 9-48 and 11-28, have been neglected.
Kurrachee ... Height in inches ...	12½	69	4½	51	2¼		3	96	11		11	39	1											
Aden ... Time	8 57	62	9 59	52	10 51	68	11 59	69	1 8	63	2 11	92	3 43	95	5 18	73	6 31	...	...	...	...	...	...	The remaining waves are small. Two waves, height 1 inch at 2-11 and 3-12, have been neglected.
Aden ... Height in inches ...	5½		1¼		3		2		9¼		1		1		4		¾							

The heights of the waves at Galle have been taken as a mean between Beypore and Negapatam. The following table has been drawn up to show the velocity, length of wave, &c., of the first 8 great waves between Galle and Aden.

Statement shewing Velocity, Length and Height of the first eight Great Waves at Galle and Aden.

Number of crests	Time of arrival at Galle	Time of arrival at Aden	Difference of time between Galle and Aden = time occupied in translation	Speed in miles per minute	Mean speed between each 2 successive crests = velocity of wave		Length of wave at Galle		Length of wave at Aden		Height of wave at Galle		Height of wave at Aden	
					Miles per minute	Miles per hour	Interval between successive crests in minutes	Interval multiplied by mean speed per minute = length of wave in miles	Interval between successive crests in minutes	Interval multiplied by mean speed per minute = length of wave in miles	Height of crest	Mean between successive crests = height of wave	Height of crest	Mean between successive crests = height of wave
	h m	*h m*	*h m*								Inches	Inches	Inches	Inches
1	2 15	8 57	6 42	6·18							18½		5½	
					6·31	379	78	492	62	391		17		3½
2	3 33	9 59	6 26	6·44							17½		1½	
					6·38	383	45	287	52	332		9½		2½
3	4 18	10 51	6 33	6·32							3½		3	
					6·27	376	61	382	68	426		7½		2½
4	5 19	11 59	6 40	6·21							12		2	
					6·17	370	64	395	69	426		11		5½
5	6 23	1 8	6 45	6·13							10		9½	
					6·24	374	77	480	63	393		9½		5½
6	7 40	2 11	6 31	6·35							9½		1	
					6·34	380	90	571	92	583		8½		1
7	9 10	3 43	6 33	6·32							8		1	
					6·36	382	99	630	95	604		9		2½
8	10 49	5 18	6 29	6·39							10		4	
					6·29	377	61	384	73	459		10		2¾
9	11 50	6 31	6 41	6·19							10		¾	

The distance from Galle to Aden is taken as 2480 miles, and 2250 fathoms or 13,500 feet may be taken as the average depth of the sea between those two places.

Thus there would appear to have passed between Galle and Aden, 8 great waves of lengths between 287 and 630 miles from crest to crest, and of velocities of from 370 to 383 miles per hour.

Velocity of the 1st great wave up the Hooghly.

The first great wave took 2 hours and 9 minutes from Dublat to Diamond Harbour (38 miles) or about 17·7 miles per hour, and 1 hour and 55 minutes from Diamond Harbour to Kidderpore (42 miles) or about 22 miles per hour, that is, the last part of the course was performed at a greater speed than the first part.

The difference of time between high water at Dublat and Diamond Harbour, and between Diamond Harbour and Kidderpore, for the particular tide in question, would appear to be 1 hour and 30 minutes and 2 hours and 21 minutes respectively.

Velocity of 1st great wave up the Bay of Bengal.

Taking the difference of time between arrival of the 1st great wave at Port Blair and at Dublat, and considering the distance as approximately 800 miles, we obtain a velocity up the Bay of about 3·1 miles per minute, or 185 miles an hour. While taking the difference of time between Vizagapatam and False Point, we obtain a rate of 4·33 miles per minute, or about 260 miles per hour; probably 220 miles per hour up the centre of the Bay is about the velocity: the average depth may be taken as 1,500 fathoms, or 9,000 feet.

Co-"Supertidal" lines.

The lines in red on the Chart show the probable position of the first great wave at each successive hour between 2 P.M. (about the hour of arrival at Port Blair) and 9 P.M. time of arrival at Aden.

Recapitulation of principal results deduced.

The following are the principal results deduced from the data available.

1. The noises of the explosions were heard at Port Blair and at Trincomalee, the distance of the latter place from Krakatoa is approximately 2,000 miles (1973 by the Chart).

2. The small tidal disturbances which occurred at the commencement and which amounted to only 3 inches at Port Blair, were traceable as far as Bombay, or about 3,100 miles from the origin, but diminished in intensity.

3. A "negative" wave preceded the great ocean disturbances, which is traceable as far as Aden, and this was probably caused by a great subsidence of the land on the coast of Java.

4. The great waves travelled from Galle to Aden at an average rate of about 378 miles per hour.

5. The lengths of the great waves varied from 287 to 630 miles.

6. The great waves diminished in height in transit from Galle to Aden in average proportion of from about 10 inches at Galle to 3 inches at Aden.

7. The average rate of the great wave up the Bay of Bengal was about 220 miles per hour, the velocity being greater along the east coast of India (Vizagapatam to False Point) than from Port Blair to Dublat.

8. The first great wave passed up the Hooghly at the rate of 17·7 miles between Saugor (Dublat) and Diamond Harbour, increasing to 22 miles per hour from Diamond Harbour to Calcutta.

Further investigation might be carried out to show the diminution in height of the waves after passing over great distances, &c.; but this may be properly left for treatment by other hands; and sufficient facts have been given to prove that "Supertidal" waves have been propagated over a distance of nearly 4,500 miles (Krakatoa to Aden), and recorded with great accuracy after travelling that enormous distance.

ADDENDUM.

I asked the Private Secretary to H. E. the Governor of Bombay to write to H. M's Consul at Batavia for certain information, and I received a reply dated Batavia, 31st October 1883, as follows:—

BATAVIA.

"In reply I would mention that owing to the sudden and unexpected nature of the catastrophe, the accounts hitherto published still require verification. The Netherlands India Government is collecting statistics from various quarters with regard to the late volcanic disturbances and the effects on the neighbouring shores of Java and Sumatra, and I shall endeavour to send you the official report, whenever it appears in print. In the meantime I can give you the following information with reference to the special points on which you wish to be enlightened."

"The first wave which occurred at Batavia approached the shore with great rapidity, at 12-10 P.M. (mean local time) on the afternoon of the 27th August, and caused the water in the new harbour to rise to a height of about 7 feet 8 inches above the normal water level at the time. The flood occurred before the ebb, the latter setting in strongly about a quarter of an hour later."

"The water continued sinking till 1-30 P.M. at which time it had receded to 10 feet 2 inches below the normal water level, making the total fall about 17 feet 10 inches. The tide remained at this low level for about an hour; at 2-30 P.M. a second wave occurred

"causing the water to rise to a height of 6 feet 4 inches above its normal level; this time "the tide ebbed as quickly as it had flowed, receding to 4 feet 10 inches below the normal "level; at 4-30 P.M. a third wave was experienced, which reached about 2 feet above the "normal level and receded to 1 foot 4 inches below same. At 8 P.M. the water was 3 feet "11 inches above its proper level, and during the whole following night it ebbed and flowed "with gradually decreasing intensity."

"Owing to the conformation of Batavia Bay, and its sheltered position, the force of the "wave was broken before it reached the shore. The effects were therefore not nearly so dis-"astrous as at some places on the coast immediately to the westward of the city, where "whole villages were washed away and hundreds of natives perished. Along the shores of "the Sunda Straits, where the wave spent its principal violence, it rose to a height of nearly "100 feet and devastated the whole of the neighbouring coasts of Java and Sumatra, causing "great destruction of life and property, details of which you have doubtless learned from "other sources."

"I may further state that the astronomical clock here stopped at $11^h\ 32^m\ 18^s$ (Batavia "mean local time) on the night of the 26-27th August."

The negative wave not seen at Batavia.

From the configuration of the Straits of Sunda, any tidal disturbance near Krakatoa would be felt in a modified form at Batavia; thus suppose a great subsidence of the subaqueous strata in the vicinity of Krakatoa, there would be a tremendous rush of water from all round into the area included by the "Meizoseismal circle or zone", and the greater supply would certainly come from the Indian Ocean through the mouth of the funnel-shaped Straits of Sunda. Of course there would be a great rush through the rest of the straits between St. Nicholas Point in Java and the small promontory on the opposite coast of Sumatra, but this indraught would be fed by a great expanse of sea beyond, and thus the disturbance at Batavia would be comparatively small and might easily escape the notice of onlookers.

It will be remarked that the Consul takes note, (that the flood occurred before the ebb) in recording the arrival of the 1st great wave.

The effect of the narrow neck of the straits above referred to would almost appear to have modified the great wave disturbance so much that each alternate wave was only noticed at Batavia, for assuming the 1st great wave at Batavia to correspond with the first one at Negapatam, the 2nd at Batavia would correspond to the 3rd at Negapatam, according to the intervals of time between them; and precisely the same interval is noticed between the 2nd and 3rd waves at Batavia as between the 3rd and 5th waves at Negapatam.

Time of origin of 1st great wave at Krakatoa.

By the Chart I find 31 fathoms or 186 feet as the average depth of water between Krakatoa and Batavia, and from Table III, para. (174), *Airy's Tides and Waves, Encyc. Met.*, I calculate that a "free wave" whose centre of impulse was at Krakatoa would take almost precisely 2 hours to travel to Batavia, 105 miles being taken as the distance.

Two hours earlier than 12-10 P.M. brings us to 10-10 A.M. Batavia mean time, and applying the correction for W. longitude, we obtain 9-19 A.M. (Port Blair time) of the 27th August, as the time of origin of the 1st great wave at Krakatoa.

Velocity of 1st great wave between Krakatoa and Negapatam.

Accepting the above as the time of departure of the 1st great wave from Krakatoa, its time of arrival at Negapatam being 3-22 P.M. (Port Blair time) we get 6-3 or say 6 hours approximately as the time occupied in transit between those two places.

The distance of Negapatam from Krakatoa is approximately 2130 miles, thus we obtain 355 miles per hour as the velocity of the 1st great wave.

But the rate across the open sea is probably greater, because the effect of the comparatively shallow water, on the north side of the Straits of Sunda, and just beyond the mouth of the Straits in the course to Negapatam, has not been taken into account.

MAURITIUS.

Account of great tidal wave extracted from the issue of *Nature*, dated 25th October 1883. The negative wave observed at Mauritius.

Nature of the 25th October 1883 gives an account of the tidal disturbances of the 27th and 28th August at Port Louis in Mauritius, which has been derived from various sources. It will be seen that the first disturbance which is recorded is as follows:—

"Towards 2 P.M. on August 27th, Captain Ferrat who was "then on board of his vessel observed that in that part of the Harbour the sea suddenly "receded, leaving the rocks in the neighbourhood dry. The level of the water it is said "fell to the extent of 4 or 5 feet." This appears to shew that the negative wave was felt at Mauritius.

Arrival of the 1st great wave at Mauritius.

Continuing the account above referred to, we find that about a quarter of an hour afterwards, the sea regained its former level with extreme violence. This would give the arrival of the 1st great wave as 2-15 P.M. local time at Port Louis.

Towards the end of the account from Mauritius, given in *Nature*, there is another report of the commencement of the disturbance as follows:—

"On the opposite side of the Trou Franfarou, another observer noticed about 2 P.M. on "the 27th, that around the *Stella* which was moored within 25 yards of him, the water had a "boiling appearance. The water then receded about 20 feet from the shore, leaving some

"boats near him partly on dry land. About a quarter of an hour afterwards the water "rushed back and advanced about 6 feet farther inland than where it was at 2 P.M."

Thus it may be taken as fairly correct that the crest of the first great wave reached Port Louis at 2-15 local time, and applying the correction for west longitude ($2^h\ 21^m$), this would correspond to 4-36 P.M. Port Blair time.

Velocity of the 1st great wave between Krakatoa and Mauritius.

We have the data for calculating the velocity of the 1st great wave between the Straits of Sunda and Mauritius.

	Port Blair Time.
	h m
Time of departure from Krakatoa	9 19 A.M.
Time of arrival at Port Louis	4 36 P.M.
Interval or time of transit from Krakatoa to Port Louis	7 17

By the method given in the description and use of the tables under the heading "Mercator's Sailing" in *Hutton's Logarithm Tables*, the distance of Port Louis from Krakatoa has been calculated as 3,400 miles, approximately. Thus $\frac{3{,}400}{7^h\ 17^m}$ or $\frac{3{,}400}{437^m}$, gives the speed of 7·78 miles per minute, or 467 miles per hour as the velocity of the 1st great wave between Krakatoa and Mauritius.

PORT ELIZABETH, SOUTH AFRICA.

In the same number of *Nature*, October 25th, a very brief account is given of the tidal disturbance at Port Elizabeth, South Africa: but fortunately there is shewn a copy of the diagram of the Self-registering Tide Gauge at that station.

Extract given from *Nature*, October 25th, 1883.

The tidal diagram at Port Elizabeth is given on such a very small scale for time and is altogether wanting in height scale, that it is impossible to measure the time of arrival, intervals, and heights of the several great waves, but an inspection of the curves shews at once the very great similarity in the tidal disturbance as recorded on the Self-registering Tide Gauge diagrams of Port Elizabeth, Beypore and Negapatam.

Similarity of the tidal curves at Port Elizabeth, Beypore and Negapatam.

As nearly as can be estimated from the diagram, the crest of the 1st great wave arrived at Port Elizabeth at 4-30 P.M., local time, and applying the difference of time for west longitude ($4^h\ 29^m$), we obtain 8-59 P.M. Port Blair time as the moment of arrival.

Time of arrival of crest of first great wave at Port Elizabeth.

The distance of Port Elizabeth from Krakatoa has been computed in a similar way to the distance of Port Louis, Mauritius, and found to be 5,450 miles approximately.

Velocity of 1st great wave between Krakatoa and Port Elizabeth.

	Port Blair Time
	h m
Time of departure of 1st great wave from Krakatoa ...	9 19 A.M.
Time of arrival at Port Elizabeth	8 59 P.M.
Interval = time of transit to Port Elizabeth	11 40

$\frac{5450}{11^h\ 40^m}$ or $\frac{5450}{700^m}$ = 7·78 miles per minute = 467 miles per hour, the rate between Krakatoa and Port Elizabeth.

It will be observed that the speed of the 1st great wave between Krakatoa and Mauritius and between Krakatoa and Port Elizabeth, is precisely the same, *viz.*, 467 miles per hour: this affords an interesting corroboration of the time accepted as the origin of the disturbance being fairly correct.

Corroboration of time accepted for the origin of the disturbance.

There are no obstructions of any kind to the passage of the wave between the Straits of Sunda, Mauritius and Port Elizabeth, and the sweep across the ocean is quite unfettered, whilst between Galle and Aden there are the Maldive and Lakadive Islands which must exercise a retarding influence. Thus the speed of the 1st wave (taking the crest velocity in this case) between Galle and Aden being only 6·18 miles per minute = 371 miles per hour, as compared to 467 miles per hour between the Straits of Sunda and Port Elizabeth, is not surprising.

The velocity greater between Straits of Sunda, Mauritius and South Africa, than that between Galle and Aden.

The time of the arrival of the crest of the 1st great wave at Galle has been accepted as 2-15 P.M. Port Blair time, and its departure from Krakatoa is taken as 9-19 A.M., thus the difference 4 hours 56 minutes gives the time occupied in transit.

Velocity of 1st great wave from Krakatoa to Galle.

The distance between the places is taken as 1960 miles, therefore $\frac{1960}{296^m}$ = 6·62 miles per minute or 397 miles per hour.

It will be objected that the velocity between Krakatoa and Galle is obtained from data which is not strictly reliable, because the time of departure from Krakatoa and of arrival at Galle has in neither case been recorded exactly. But the velocity deduced 397 miles is not very different from a mean between 355 miles—(the velocity from Krakatoa to Negapatam)—and 467 miles (the velocity between Krakatoa and Port Elizabeth).

Time of arrival of the 1st great wave at Galle fairly well corroborated.

This seems to shew that the accepted time of arrival at Galle cannot be much in error.

The time of arrival of the 1st great wave at Port Blair is 1-55 P.M., its departure from Krakatoa is 9-19 A.M. which gives $4^h\ 36^m$ as the interval occupied in transit between these two places. The distance may be taken as 1550 miles, therefore $\frac{1550}{276^m} = 5 \cdot 62$ miles per minute, or 337 miles per hour may be considered the speed of the 1st wave between Krakatoa and Port Blair.

Velocity of the 1st great wave between Krakatoa and Port Blair.

Recapitulation of velocity of the 1st great wave.

The following is the comparative statement of the velocity of the 1st great wave :—

From	To	Miles per hour	Remarks
Krakatoa ...	Mauritius and Port Elizabeth	467	Passage quite unobstructed.
Galle ...	Aden	371	Maldive and Lakadive Islands intervene.
Krakatoa ...	Galle	397	Shallow water.
Do. ...	Negapatam	355	North part of mouth of Straits of Sunda decreases velocity.
Do. ...	Port Blair	337	

Accepting 467 miles as the velocity of the great waves between Krakatoa and Port Elizabeth, we find from Table III, para. (474), *Airy's Tides and Waves, Encyc. Met.*, that the average depth of the sea along this route should be about 15,000 feet or 2,500 fathoms.

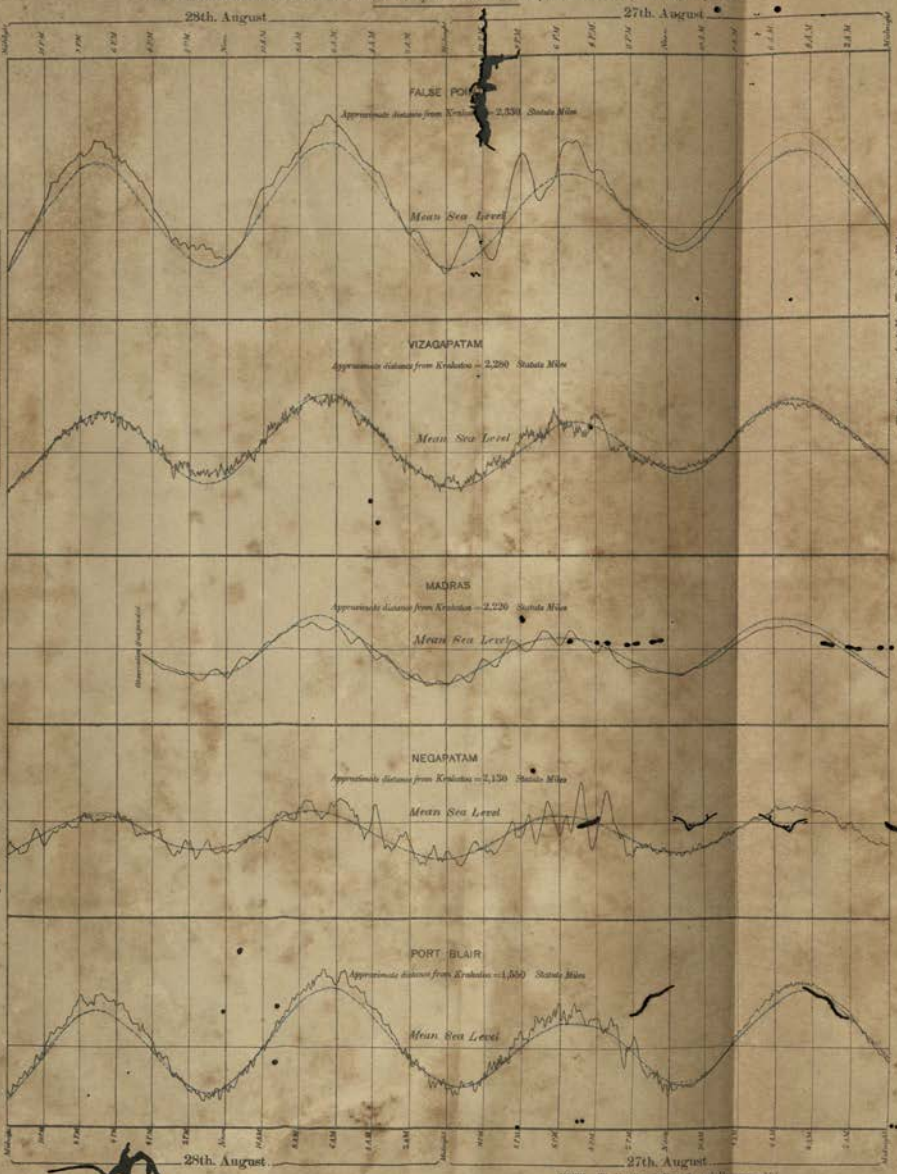
Depth of water of the ocean between the Straits of Sunda and Port Elizabeth.

The lines in red on the Chart shew the probable position of the 1st great wave at the hours indicated (by Roman numerals) on the 27th August.

"Co-supertidal" lines.

TIDAL CURVES

To illustrate the effects of the waves caused by the Volcanic Eruption at Java, 27th. August 1883.

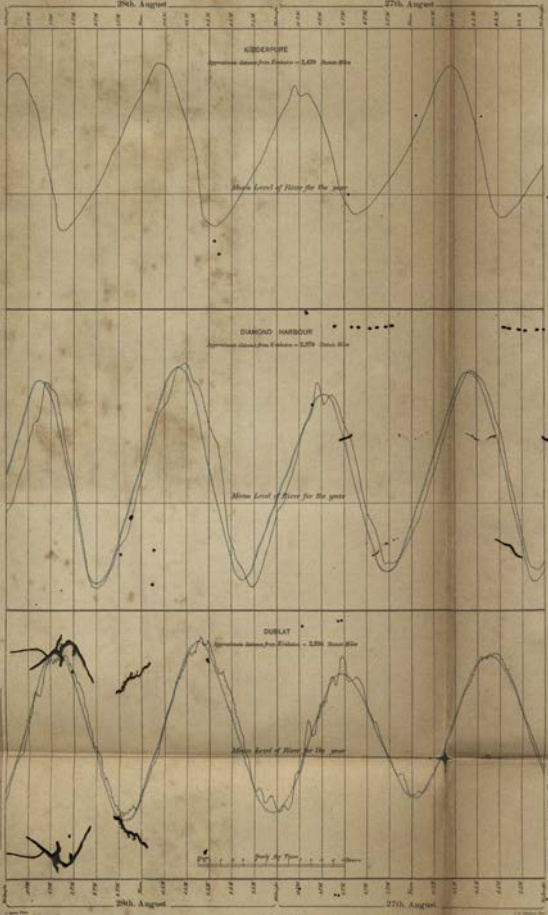


* The time lines refer to Mean Time Port Blair.
To find Krakatoa time add 51 minutes to Port Blair time

NOTE.—The blue lines indicate the probable curves which would have been recorded but for the Tidal disturbances: they have been obtained from the predicted values contained in the Tide Tables for 1883.

TIDAL CURVES

To illustrate the effects of the waves caused by the Volcanic Eruption at Java, 27th. August 1883.



TIDAL CURVES

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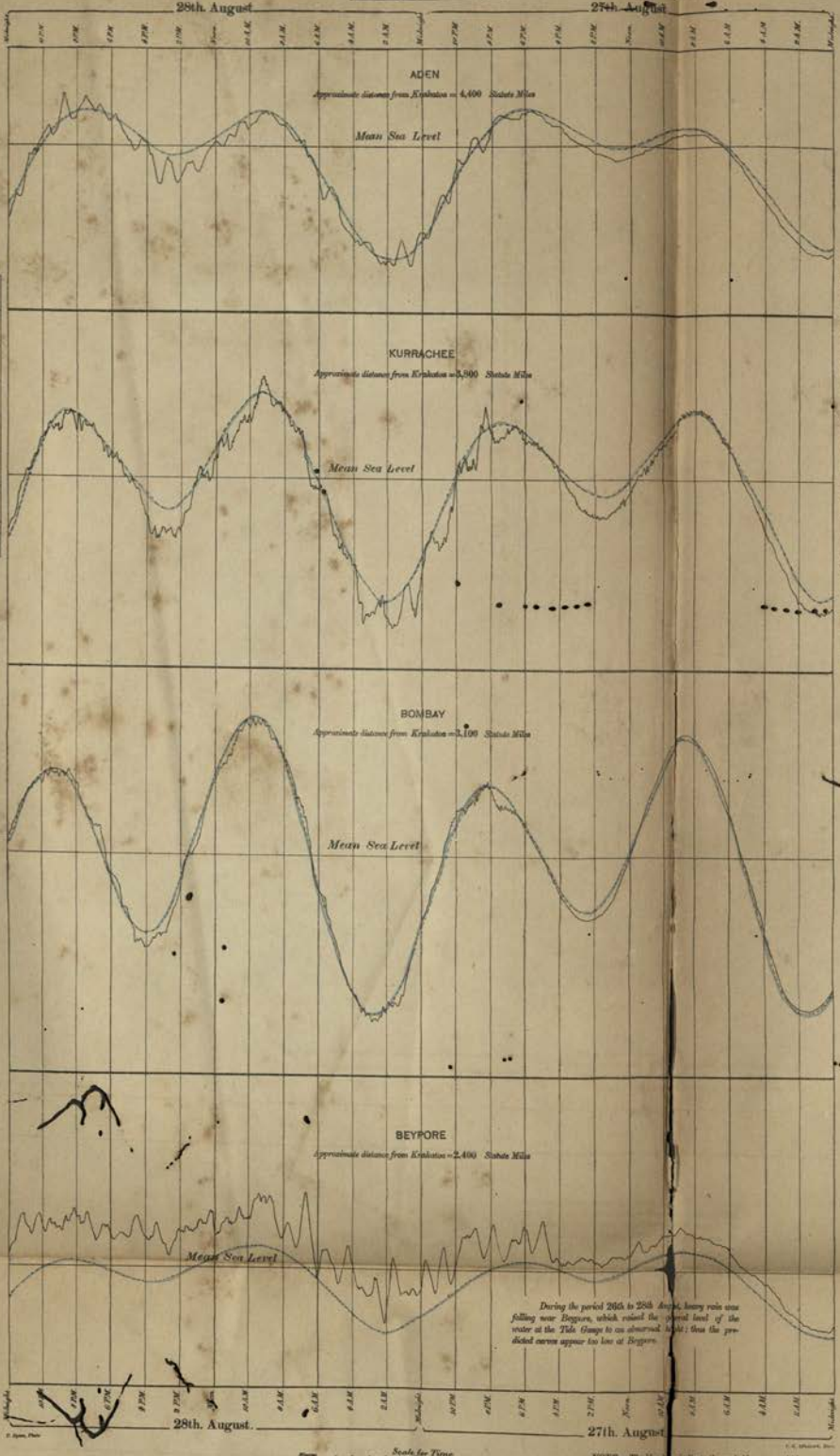
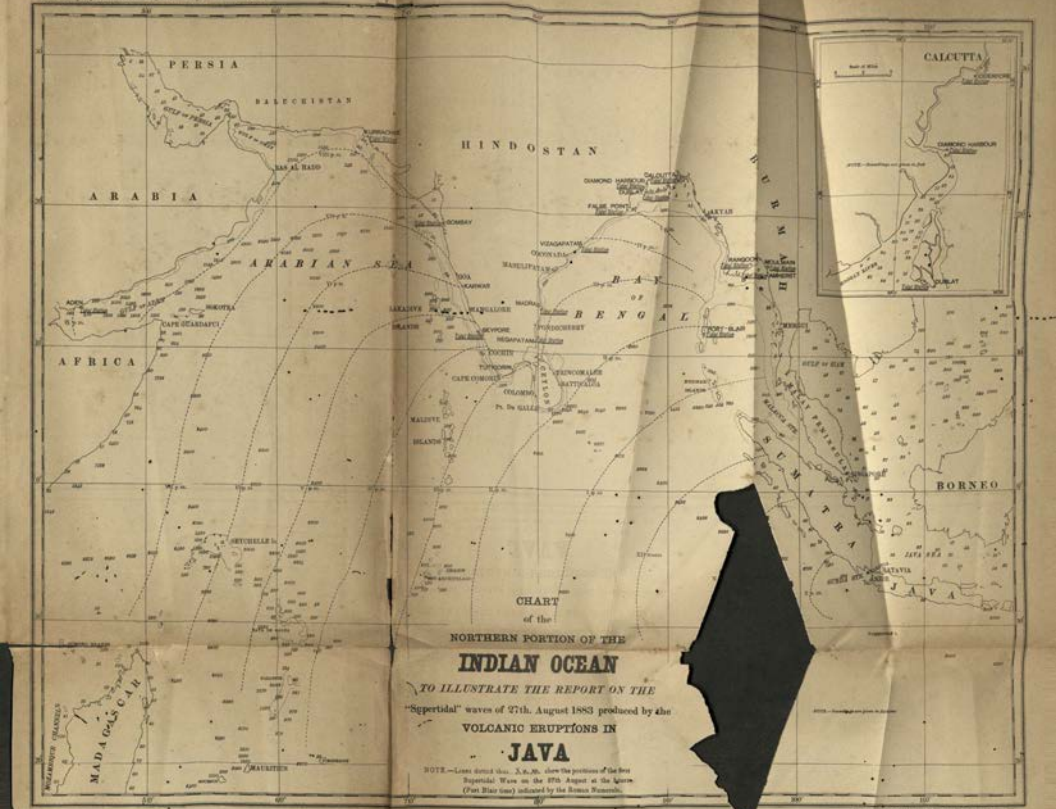

28th. August.
27th. August.
ADEN
Approximate distance from Krakatoa = 4,400 Statute Miles
Mean Sea Level
KURRACHEE
Approximate distance from Krakatoa = 3,800 Statute Miles
Mean Sea Level
BOMBAY
Approximate distance from Krakatoa = 3,100 Statute Miles
Mean Sea Level
BEYPORE
Approximate distance from Krakatoa = 2,400 Statute Miles
Mean Sea Level
Scale for Height
Feet
The time lines refer to Mean Time Port Blair. To find Krakatoa time add 1h 41m to Port Blair time
During the period 26th to 28th August, heavy rain was falling near Beypore, which raised the general level of the water at the Tide Gauge to as observed, whilst the predicted curves appear too low at Beypore.
28th. August.
27th. August.
Scale for Time.
Hours.

NOTE.—The blue lines indicate the predicable curves which would have been recorded for the Tidal disturbance: they have been obtained from the predicted values contained in the Tide Tables for 1883.

To accompany the Annual Report, Survey of India, 1882-83.



Taken from Petermann's Mitteilungen. 29. Band, 1883. XII.

MAP SHOWING CHANGES IN THE SUNDA STRAITS CAUSED BY THE ERUPTION OF KRAKATOA, 26TH AND 27TH AUGUST 1883. SCALE 1 : 500,000.

C. Dyson, Photo. C. G. Ollenbach, Zinco.

Published under the direction of Colonel G. C. DePrée, S.C., *Offg. Surveyor General of India.*

Photozincographed at the Office of the Trigonometrical Branch, Survey of India, Dehra Dún, February 1884.

After that the volcano Krakatoa (called also Krakatau or Rakata) had exhibited no signs of volcanic activity since May 1680, when it destroyed the luxuriant vegetation of the Straits of Sunda, by a shower of burning ashes, it began on 27th May 1883, to make itself again noticeable by the ejection of ashes and pumice-stones. Its continuing activity manifested itself in the following months by detonations, by belching forth columns of smoke, and culminated at last in the destructive eruption of the 26th and 27th August, which not only resulted in a total devastation of the neighbouring coasts of Sumatra and Java, partly by showers of ashes, partly by inundations, but also produced changes of the surface in the Straits of Sunda, such as are only rarely authenticated in such magnitude on the earth within historic times. The northern part of the island of Krakatoa has, except in two places, sunk into the sea with its peak Perbuatan, 822 meters high. On the other hand the island has received an addition by a new formation in the west. To the north-east of Karakatoa, and its two neighbouring islands Verlaten Island and Lang Island which remained unaltered, two new islands have emerged from the sea in the midst of the channel which ships carrying the trade between Java and Sumatra are wont to pursue. These have been named Steers Island and Calmeyer Island, after the officers of the Dutch man-of-war, which was despatched by the Government shortly after the eruption for the purpose of at once reconnoitering the possible interruptions and alterations in the channel, whilst a final authentic survey had to be postponed for a future opportunity. No change, according to the result of the soundings, seems to have taken place in the channel east of Krakatoa, which the ships bound from Java to Europe make use of: on the other hand to the north of the Island a lessening of depth is perceptible. A planimetrical calculation undertaken by us gave the following results of the

change in the Straits of Sunda :—Of the island of Krakatoa, which up to this contained (an area of) 32·5 square kilometers, 23·25 square kilometers are submerged; on the other hand it has gained 1·42 square kilometers: it now therefore possesses a superficies of 10·66 square kilometers. Of the newly-emerged islands, Calmeyer Island has an area of 2·96 kilometers, and Steers Island of 4·26 square kilometers. Consequently altogether 6·44 square kilometers of new land have emerged, whilst 23·25 square kilometers have disappeared. The Dutch possessions in Eastern Asia have lost about 14·61 square kilometers.

It is not improbable, that with these changes, which our sketch exhibits as the result of the first reconnoitering voyage, the alterations called for on the chart, will not be concluded: it is rather to be expected, that more accurate surveys, both in the Straits of Sunda themselves and also on the Coasts of Sumatra and Java, will show many variations in the former configuration of the land. For instance, the mighty earthquake wave with which the eruption was attended, and which has been traced to all the coasts of the Indian Ocean, to many points of the Great Ocean (the Pacific?) and even of the Atlantic Ocean has caused enormous destruction of territory, which is only too explicable, if we reflect on the bulk of the water which at the narrowest part of the Straits of Sunda, near Anjer and Merak, rose to a height of 30 to 40 meters. The reports hitherto made public, appear undoubtedly not always to rest upon careful examination, but may well, as regards the most important part, bring back the impression which was obtained on a flying passage: a delusion in such cases was the more easily possible, as the inundation carried away with it every thing within reach, buildings and vegetation, and smoothly shaved the ground. Thus the island of "Dwars in the channel" was subdivided into five parts; the island of Merak, and to the north of it the little islets of Taleier and Tompora (Tampora) have entirely disappeared. On the N.E. of Anjer, the sea reaches up to the foot of the hills of Kramat-watu, but it is not yet clear, whether an irruption into the Straits of Sunda, or an enlargement of the Bay of Bantam is here presented. Further to the south, the flat west coast of Java must have suffered many changes up to "Third Point," for here particularly the sphere of inundation stretches far inland, at many points more than half a mile (German?) and it is not therefore to be doubted that the powerful current of the receding waters must also have influenced the form of the coast line.

The same observation must also be made as regards the east coast of Sumatra, which was likewise exposed to an unimpeded shock of the inundation.

(The foregoing translation is complete so far as it goes and is evidently based on accurate observations: as such, it is now attached to Major Baird's report, preceding, for convenient reference. J. B. N. Hennessey.)

Trans-Himalayan Exploration Map No 15

SKETCH MAP

ILLUSTRATING THE EXPLORATIONS

OF

A K

IN

GREAT TIBET AND MONGOLIA

1879 TO 1882

(In three Sheets)

Sheet No. 1

Trans-Himalayan Exploration Map No. 15

SKETCH MAP

ILLUSTRATING THE EXPLORATIONS

OF

A——K——,

IN

GREAT TIBET AND MONGOLIA

1879 TO 1882

(In three Sheets)

Sheet No. 2

REFERENCES.

Heights in feet above sea level shown thus, 4500

Explored under the orders of Lieut.-Genl. J. T. Walker, C. B., R.E., F.R.S., &c., Surveyor-General of India, and Superintendent of Trigonometrical Surveys; and compiled under the Superintendence of H. H. Godwin-Austen, Esq., M.A., F.R.S., Offg. Deputy Surveyor-General, in charge of Trigonometrical Surveys.

Compiled by W. G. W. S. Johnson.

Scale 1 Inch = 16 Miles

Published under the direction of Colonel G. C. Dalton, R.E., Offg. Surveyor-General, India.

Photo-zincographed at the Office of the Trigonometrical Survey of India, Dehra Dún, January 1884.

Trans-Himalayan Exploration Map No. 12

SKETCH MAP
ILLUSTRATING THE EXPLORATIONS
OF
A——K
IN
GREAT TIBET AND MONGOLIA
1879 to 1892
(In three Sheets)
Sheet No. 3

Circular No. 698.

Extract from the Proceedings of the Government of India in the Revenue and Agricultural Department (Surveys), dated Simla, 18th June 1884.

Read—

The General Report on the Operations of the Survey of India during the year 1882-83, submitted with the letter from the Surveyor-General of India, No. 877-S. of the 14th April 1884.

RESOLUTION.

THE first chapter of the Report deals with the triangulation work of the year. The secondary triangulation which remained to be done, as stated in last year's Report, was taken up. One field party was employed in fixing points for the Marine Surveys. A series of secondary triangles, 97 miles in length, was executed along the east coast from the vicinity of Ichápur in the Ganjam District to the town of Pooree, which is well known as the seat of Jagannath's temple. Six beacons were erected and 115 conspicuous objects permanently fixed.

A second party took up the chain of secondary triangles required to furnish a basis for the geography of Upper Burma. Dense haze and forest fires obstructed the view of Sub-Surveyor Moung Shoay Gyoke in taking observations; but notwithstanding this, satisfactory progress was made, and the data gained will prove useful for future operations. The Government of India is glad to notice that the important work of visiting and covering in the stations of the series was carried out. The very important secondary series for the purpose of joining Singapore with India remains to be undertaken.

2. The second chapter deals with topography. Thirteen topographical parties continued their operations on the lines of previous years, except that the Rajputana party was transferred to Burma for forest survey work, and the work left unfinished in Rajputana was made over to the Gwalior and Central India party. The Bhopal and Malwa party was transferred to Mirzapur, and the survey of Malwa assigned to the Khandesh party. Including these changes the parties were thus distributed:—One in Central India and Rajputana, four in the Bombay Presidency, two in the North-Western Provinces, and the remaining six in Assam, Burma, Mysore, Kohat, Baluchistan, and on the Hooghly River.

3. The Rajputana and Central India party worked in two separate divisions —one in Gwalior and the other in the country south-west of Erinpura as well as in the desert west of Bickaneer. A total area of 846 square miles on the scale of 1″ = 1 mile, and of 5,534 square miles on the ½-inch scale was completely surveyed by the entire party.

A re-survey of the city and environs of Jeypore, required on account of alterations and additions to buildings and sites caused by the construction of the Rajputana Railway, was undertaken; but the work was unavoidably stopped and put off for the next season's operations, when the revision of the Ajmere city map will also be resumed.

4. Of the four parties employed in Bombay, the Khandesh party succeeded in completing the survey of that district, including certain outlying villages in the territory of His Highness the Nizam. This party then resumed the survey of Malwa and triangulated 600 square miles of ground in advance of topography.

5. The work of the Guzerat party was described in the remarks on the Report for 1881-82. This year the survey of the Dang Forests was completed, as well as the remaining portion of British territory which had to be surveyed on the 2-inch scale. The total area surveyed during the season was 1,331·7 square miles.

6. The Cutch party continued its work of previous years. The area of this year's operations includes the towns of Mundra, Naliya, Jakhawu, Tera, Kothara, and Suthri, besides two places of pilgrimage—Matanomadh (Mhur), noted for manufacture of alum, and Narayan Sarovar. In all 1,632 square miles was topographically surveyed and a considerable area was traversed and triangulated in advance.

7. The Deccan party continued the survey of the Southern Collectorates, and completed a total area of 1,800 square miles, of which 1,509 square miles are in the districts of Sholapur, Satara, and Ratnagiri, and the remaining areas in the dependent States of Anudh, Akalkot, Miraj Senior, and Jamkhandi. The survey of the municipal town of Pandharpur was carried on during the season. The town is an important pilgrim centre, and the work was somewhat impeded by the large crowds attracted to the many fairs which are held there.

8. The work assigned to the Mirzapur survey party (late Bhopal-Malwa party) was as follows:—

(1) the 2-inch survey of parganas Agori, Singrauli, and Dudhi, lying south of the Kaimur range and the river Sone;

(2) several hilly and forest tracts, partly on the 2-inch and partly on a 16-inch scale, which were left unsurveyed by the Revenue Survey party which was lately employed on the cadastral survey of the northern part of the district.

A small portion of the party which had been left behind in Bhopal completed the Bhopal and Malwa survey in the Central India Agency, and has now joined the head-quarters of the party at Mirzapur.

9. The second North-Western Provinces party was employed chiefly in the Bulandshahr and Aligarh Districts on the survey of the Dooab between the Ganges and Jumna. The civil station and city of Aligarh was also surveyed. It is satisfactory to notice the measures taken for the preservation of traverse stations as suggested by the Government of India in its Circular Resolution No. 45-S., dated the 4th September 1882. The continuance of Topographical parties in districts where the Settlement Department has already provided tolerably serviceable maps, is, however, of doubtful expediency, and the Topographical work of the North-Western Provinces party will probably be suspended pending the examination of the maps provided by recent settlement operations in the remaining districts on the list of tracts requiring Topographical Survey in the North-Western Provinces.

10. The Assam topographical party completed its work in South Sylhet, together with a large scale survey of Shillong. This party has been divided, one portion of it having undertaken a survey of the Andaman Islands, whilst the second half will be employed in surveying the head of the Dehing valley and the unexplored portion of the Patkoi range. This portion of the party also undertook a survey of the country inhabited by the Akas, the hill tribe which recently committed a raid on British territory.

11. A special topographical survey party was organized for British Burma at the Chief Commissioner's request to perform the following descriptions of work:—

(*a*) the survey of all lands remaining to be cadastrally surveyed,

(*b*) the survey of all hilly tracts,

(*c*) the survey of reserved forests.

Great difficulties were experienced in the season's operations from the hilly nature of the ground and the dense forests and the extreme unhealthiness of the country. The party was prostrated by fever, and the native establishment suffered greatly from dysentery and other malarious diseases.

The surveys were commenced on the usual topographical scale of 4″ = 1 mile, full details being shown as has hitherto been done in the case of other forest surveys; but with a view to expediting the completion of the work, and in order to lessen its cost, the Chief Commissioner has decided on adopting a modified 4-inch scale of survey, in which only the more important details will be given.

In addition to the forest surveys, it is proposed, if possible, to commence the mapping of the country between the Irrawaddy and Mimakha rivers.

12. The Mysore topographical party continued its work in that province and completed a total area of 4,614 square miles. Next season the town of Mysore and the town and cantonments of Bangalore will be surveyed in addition to the regular work of the party.

13. The Kohat party completed the survey of the district together with a large scale survey of the city and cantonment of Kohat.

14. *The Baluchistan survey.*—The principal work of this party was triangulation which was commenced at the Great Indus series and extended over the Suleman range through the Khetran country to the Marri hills. The topography of the year was carried on in the hilly country east of Kalat, also at the foot of the hills and in low country north of Sibi. The extremes of heat and cold between the autumn and winter months render it impossible for the party to work in any one locality throughout the field season.

15. The Hooghly river survey from Saugor Island to Baranagar near Barrackpore was completed, the map having been supplemented by soundings and river survey details measured by the Marine Survey Department.

16. *Mauzawar or village surveys.*—One party was employed in the Hissar district in the Punjab and made very good progress, having completely surveyed an area of 1,500 square miles, besides a good deal of traversing and the marking of traverse stations.

This survey, which was originally intended to be purely topographical, is now being carried on on the usual topographical scale of 2″ = 1 mile; but it assumes the nature of a mauzawar survey, inasmuch as it shows village boundaries and includes the determination of village areas. It also includes the determination of fixed points within the village areas, which will serve as the basis of a field survey when this is required for settlement purposes. It is anticipated that with the help of these points the village patwaris will be able to undertake the field survey on a scientific basis. The experiment is one in which the Government of India takes great interest, as it may lead to an important reform in the system of settlement surveys.

17. A second party was employed in Bombay, and completed the survey of 663 square miles in the Tanna district, besides a small area in the Jawar State.

18. The cost at which the work of each topographical party has been performed per square mile is not clearly shown. On this point supplementary information is desired. In future reports the expenditure incurred by the several parties should be included in the report, and in any case in which the cost exceeds a fair average rate an explanation should be given.

19. *Cadastral or field surveys* were carried on by two parties in the North-Western Provinces and by three in British Burma. One party in the North-Western Provinces completed the cadastral survey of the Ballia district together with a *mauzawar* survey of certain villages in the Shahabad and Sarun districts of Bengal. Operations were also commenced in Benares. A system new in form but the result of prolonged experiment and experience has been adopted in this district, which admits of the settlement establishment and the survey staff working in co-operation. The *khasras*, or village field books, are written up at the time of survey, and the *jamabandi* (or rent roll) slips compiled at recess quarters. The system is fully described in a joint memorandum by Mr. F. W. Porter (Settlement Officer) and Major W. Barron (Deputy Superintendent of Survey), and is appended to the report. The second cadastral party in the North-Western Provinces completed the field survey of Mirzapur and then commenced work in Gorakhpur.

20. In British Burma one party was employed in the Hanthawaddy district and cadastrally surveyed the Hmawbee township.

The other two parties were employed respectively in the Bassein-Henzada and in the Tharrawaddy-Prome districts.

All the cadastral surveys which were required in the Hanthawaddy and Tharrawaddy districts have now been completed, but large tracts in both districts remain to be topographically surveyed.

21. The surveys in Darjeeling were carried on in three different localities:—

(*a*) the revisionary survey of the district west of the Teesta and (*b*) the survey of Sikkim (both of which were completed);

(*c*) the Nepal boundary survey from the Kosi to the Gandak.

The whole boundary line requires restoration, and the work has been sanctioned by the Government of India.

22. Chapter XXIV (Geographical) contains a useful and interesting summary of the additions made during the course of the year to our geographical knowledge of the frontier. Reconnaisances were made beyond the British border into Afghanistan, which resulted in the completion of the frontier surveys up to the Gumal valley. A survey of the Jowaki hills was also completed by Munshi Esuf Sharif, to whom, as well as to Major Holdich and Messrs. Claudius and McNair, great credit is due for energy, courage, and professional skill.

A map of A—— K——'s geographical discoveries in Mongolia and Great Thibet is attached to the report and a full account of his explorations is reported to be under preparation. The Government of India awaits with interest the submission of this report, which promises to add largely to the existing geographical knowledge of those countries, and to throw light on the problems connected with the sources of the great rivers of the Burma peninsula. It may be noticed that the 1st class medal of the Geographical Society of Italy, which was placed at the disposal of the Surveyor-General for presentation to the most meritorious explorer, has been awarded to A——K——.

23. Among the purely scientific work of the Department, Major Baird's report on the tidal disturbances caused by the volcanic eruption at Java in August last is a valuable record of the effect of this memorable convulsion on the oceanic tides, as observed on the Indian coast. Tidal observations were also conducted, as usual, during the year at the various tide-registering stations under Major Baird's supervision, and the analysis of the results has been much aided by the advice and suggestions of Professors Darwin and Adams.

24. The spirit-levelling operations were carried on and completed on several branch lines from Diamond Harbour to Chinsurah; the line of spirit levels between the sea levels at Kurrachee and False Point was also completed.

25. The second part of the report deals with the operations of the Head-Quarters Offices of the Department. The Photographic and Lithographic Branches turned out a very satisfactory amount of work, and the results reflect considerable credit on Major Waterhouse and other officials connected with this section of the Department. In the Mathematical Instrument Department, 8,346 instruments were manufactured, being 664 less than the number manufactured in the preceding year, but the number of instruments repaired during the year was 25 per cent. greater than in 1881-82.

Very good progress was made in the Drawing Office. New maps of the North-Western Provinces and of the Punjab and a map of the Nizam's dominions are in course of completion; a complete series of provincial index maps are being prepared, and 5,195 cadastral maps were published. Three maps of India were also specially made for the Calcutta Exhibition.

26. The following is a comparative statement of the cost of cadastral surveys during the past three years:—

	Average cost per square mile.		
	1880-81.	1881-82.	1882-83.
	Rs. A. P.	Rs. A. P.	Rs. A. P.
In the North-Western Provinces...	159 4 11	138 13 3	150 5 1
In British Burma	250 8 7	232 4 9	266 14 11

It would thus appear that the cost of cadastral surveys in both Provinces is greater than it was in the preceding year, while in Burma it is even higher than it was in 1880-81. It is extremely desirable that every effort should be made to keep down the cost of these surveys, in order that they may compare as favourably in point of expense with non-professional field surveys as they do in point of accuracy. At the same time the Government of India has great reason to be satisfied with the effect of the improvements introduced into the system in the North-West Provinces by Major Barron and other officers in connection with the cadastral surveys there in progress. And it is hoped that the experiment now being tried by the topographical party in Hissar may also lead to valuable results. The financial advantage of combining, as far as possible, topographical with revenue surveys, is manifest, and it would, for that reason, be undesirable, as has been urged elsewhere, to dissociate the Surveyor-General's Department too entirely from cadastral operations. It cannot be too strongly repeated that the willingness of Local Governments to employ cadastral parties supplied by the Survey Department on surveys for the cost of which the provincial revenues are to a great extent responsible, depends in no small degree on the extent to which the Survey Department is prepared to meet their financial requirements even at some sacrifice of scientific completeness and accuracy. As the Survey Department is maintained at a considerable cost to the Imperial Government, the Government of India, though not desiring to interfere with provincial arrangements in this respect, is anxious that the Department should be as extensively employed as is possible in executing the land revenue surveys of the country, and it trusts that this object may be found capable of attainment.

ORDER.—Ordered that copies of the Resolution be forwarded to the Surveyor-General of India, to the Local Governments and Administrations noted in the margin, and to the Foreign and Military Departments.

Madras.
Bombay.
Bengal.
North-Western Provinces and Oudh.
Punjab.
Central Provinces.
British Burma.
Assam.
Coorg.

(True extract.)

E. C. BUCK,
Secretary to the Government of India.

1884.

GOVERNMENT OF INDIA.

REVENUE AND AGRICULTURAL DEPARTMENT.

SURVEYS.

RESOLUTION.

Circular No. 69S.

Dated Simla, the 18th June 1884.

SUBJECT.

Reviews the General Report on the operations of the Survey of India Department during the year 1882-83.

G. C. H. Press, Simla.—No. 195 R. F. A. D.—19-6-84.—1,250.

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